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DIGITAL INFORMATION SYSTEM, DIGITAL AUDIO SIGNAL  
PROCESSOR AND SIGNAL CONVERTER

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1 BACKGROUND OF THE INVENTION

The present invention relates to a digital information system, a digital audio signal processor and a signal converter, such as a digital information system for realizing sale or supply of specified audio data or the like by transmitting it to a specified person in the form of electrical signal, an audio signal processor and a signal converter suitable for the system, and a technique effectively used for a data compressing and expanding circuit.

As a conventional example of commercialized information, there is a newspaper or magazine on which characters or the like are printed by use of paper as a medium. The paper used in this way may be replaced by various types of software sold through a memory medium such as floppy disk, or IC card. Another example is communication means such as cable television or satellite broadcasting for supplying news or broadcast programs to specified subscribers.

Further, a portable computer, which unlike the conventional notebook-type personal computer or "electronic notebook", can easily send a message to another person, access a data base, or process information without being restricted by time or place, has been suggested in "Nikkei Electronics", November 26, 1990,

5           Also, a system for transmitting and receiving  
information is disclosed in JP-A-63-61391.

10 SUMMARY OF THE INVENTION

In the case where information is commercial-  
ized and sold by use of paper as a medium as in news-  
papers or magazines, the printing and transportation  
take long time, which not only makes the system un-  
suitable for timely sale of information, but also  
adversely affects the earth environment by deforestation  
for making paper and discharging information garbage.  
In the case where a IC card or floppy disk is used as a  
medium as in the electronic notebook or the like, a  
terminal device such as the electronic notebook or  
personal computer is needed. In addition, these  
terminal devices presuppose information processing such  
as in the electronic notebook, so that the operation  
thereof is comparatively complicated and difficult in  
application, thereby preventing general extension of the  
use thereof. Also, in the case where a great amount of  
data are distributed through FM broadcasting, it is

5                   Accordingly, the present inventors have  
developed a digital information system which makes it  
possible to deliver and receive information in the same  
form as general commodities as an electrical signal  
while at the same time reproducing the received  
10 information by an ultrathin portable memory card with  
the playback function, and a digital audio signal  
processor and a signal converter suitably used  
therewith.

Another object of the present invention is to realize transfer of digital signals between a digital signal source and a memory card with a playback function mentioned above, at a rate at least higher than the signal to be processed in the digital information system.

A further object of the present invention is to provide a method and an apparatus for various types

A still further object of the present invention is to provide a method and an apparatus for efficiently transferring and assuring confidentiality of information in the above-mentioned digital information system.

20           In this digital information system, for  
example, a digital signal is received from a digital  
signal source and delivered to a memory card with a  
playback function at a speed at least higher than the  
signal to be processed. Also, between an original  
25 source of digital signals and a digital signal source, a  
digital signal is received and stored through a  
communication channel or an appropriate storage medium  
as required, while at the same time receiving a



1 specified digital signal by the connection through a  
connector with the memory card having playback function  
(player). Further, the memory capacity of the terminal  
device is equal to or more than that of the memory on  
5 the memory card with playback function, and the terminal  
device is used with a hard disk memory unit having a  
comparatively large memory capacity as a backup memory.  
At the same time, the digital signal frequently received  
and delivered with the memory card having the playback  
10 function or the digital signal updated with the lapse of  
time is stored in a buffer memory configured of a  
semiconductor memory accessible at high speed, thereby  
making possible efficient receiving and delivery of  
information. Furthermore, the storage area of a memory  
15 in the memory card with playback function is controlled.  
In addition, the above-mentioned terminal device  
realizes a digital information system having the  
function of audition with a part of designated digital  
signals reproduced and outputted over a predetermined  
20 length of time, and having an ultrasmall, ultrathin  
memory card with playback function as the result of  
slow/fast playback by voice interval control and  
neglection of quantizing noises.

The player receives a digital signal in the  
25 form of electrical signal, and independently play backs,  
so that the value of the digital signal received can be  
exhibited in direct form. As a consequence of the  
usability of a digital signal in direct form, a system

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1 for processing, production and sale thereof is  
configured easily. At the same time, the simple player  
construction in the form of an ultrasmall, ultrathin  
card, offers the handling ease for every user. By  
5 enlarging or extending the voice interval of the digital  
audio signal substantially, the slow or fast playback is  
made possible without deteriorating the audio quality.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing the  
10 essential parts of a digital information system  
according to an embodiment of the present invention;

Fig. 2 is a block diagram showing an input  
section of the terminal device of Fig. 1;

Fig. 3 is a block diagram showing a memory  
15 section of the terminal device of Fig. 1;

Fig. 4 is a block diagram showing an output  
section of the terminal device of Fig. 1;

Fig. 5 is a block diagram showing the  
essential parts of a data input section of a player;

20 Fig. 6 is a block diagram showing the  
essential parts of a data output section of the terminal  
device of Fig. 1;

Fig. 7 is a block diagram showing an  
embodiment of the player used with a digital information  
25 system according to the present invention;

Fig. 8 is a plan view showing an embodiment of  
a package board configuring the player;

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1           Fig. 9 is a side view showing an embodiment of  
a package board accommodated in a case;

          Fig. 10 is a plan view showing another  
embodiment of the player;

5           Fig. 11 is a block diagram showing an  
embodiment of the player body and the memory section of  
Fig. 10;

          Fig. 12 is a block diagram showing an  
embodiment of a power supply system of the player;

10           Fig. 13 is a diagram showing the configuration  
of an embodiment of the digital signal transferred from  
a terminal device to the player;

          Fig. 14 is a block diagram showing an  
embodiment of the player corresponding to the digital  
15 signal with the ID signal of Fig. 13 inserted therein;

          Fig. 15 is a circuit diagram showing an  
embodiment of a quantizing noise remover according to  
the present invention;

          Fig. 16 is a diagram showing waveforms for  
20 explaining an example of the operation of the quantizing  
noise remover of Fig. 15;

          Fig. 17 is a circuit diagram showing an  
embodiment of a security circuit used in a digital  
signal selling system according to the present  
25 invention;

          Fig. 18 is a circuit diagram showing another  
embodiment of the security circuit used in a digital  
signal selling system according to the present

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1 invention;

Fig. 19 is a circuit diagram showing still another embodiment of the security circuit used with a digital signal selling system according to the present invention;

Fig. 20 is a circuit diagram showing a further embodiment of the security circuit used in a digital signal selling system according to the present invention;

10 Fig. 21 is a circuit diagram showing a still further embodiment of the security circuit used in a digital signal selling system according to the present invention;

Fig. 22 is a specific circuit diagram showing an embodiment of a bit exchanger used in the security circuit of Fig. 21;

Fig. 23 is a circuit diagram showing an embodiment of the security circuit suitable for copy prevention used in a digital signal selling system according to the present invention;

Fig. 24 is a circuit diagram showing another embodiment of the security circuit suitable for copy prevention used in a digital signal selling system according to the present invention;

25 Fig. 25 is a circuit diagram showing still another embodiment of the security system suitable for copy prevention used in a digital signal selling system according to the present invention;

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1           Fig. 26 is a circuit diagram showing a further  
embodiment of the security circuit suitable for copy  
prevention used in a digital signal selling system  
according to the present invention;

5           Fig. 27 is a specific circuit diagram showing  
an embodiment of the bit exchanger used with the  
security circuit of Fig. 26;

          Fig. 28 is a circuit diagram showing a still  
further embodiment of the security circuit suitable for  
10 copy prevention used in a digital signal selling system  
according to the present invention;

          Fig. 29 is a specific circuit diagram showing  
an embodiment of the bit exchanger used with the  
security circuit of Fig. 28;

15          Fig. 30 is a block diagram showing an  
embodiment of a digital audio signal processor for  
realizing the fast and slow playback according to the  
present invention;

          Fig. 31 is a block diagram showing a specific  
20 example of a fast playback circuit according to the  
present invention;

          Fig. 32 is a block diagram showing a specific  
example of the slow playback circuit according to the  
present invention;

25          Fig. 33 is a diagram showing waveforms for  
operation corresponding to the fast playback circuit of  
Fig. 31;

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1           Fig. 43 is a block diagram showing an  
embodiment of a digital signal playback circuit  
including the fast/slow playback mode for a digital  
signal representing a compressed data;

5           Fig. 44 is a block diagram showing an  
embodiment of a data converter configured of a data  
conversion system according to the present invention;

          Fig. 45 shows waveforms for explaining an  
example of the analog-to-digital conversion involving  
10 the data compression of Fig. 44;

          Fig. 46 is a block diagram showing another  
embodiment of a data converter configured of a data  
conversion system according to the present invention;

          Fig. 47 is a block diagram showing an  
15 embodiment of a digital-to-analog converter according to  
the present invention;

          Fig. 48 shows waveforms for explaining an  
example of operation of the digital-to-analog converter  
of Fig. 47;

20           Fig. 49 is a block diagram showing another  
embodiment of a digital-to-analog converter according to  
the present invention;

          Fig. 50 is a block diagram showing still  
another embodiment of a digital-to-analog converter  
25 according to the present invention;

          Fig. 51 is a fundamental block diagram showing  
an embodiment of a switch input circuit of a player used  
in a digital signal receiving/delivery system;

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Fig. 69 is a diagram specifically showing the appearance of still another embodiment of a digital signal receiving/delivery system according to the present invention.

A block diagram of essential parts of a digital signal transmitting receiving system according

1 to an embodiment of the present invention is shown in  
Fig. 1. This embodiment is intended for a system to  
commercialize and sell information of a digital signal.  
In other words, the sale of the information is made  
5 available as one of forms of transmitting receiving of a  
digital signal.

In Fig. 1 is shown a block diagram of a terminal device of a digital signal selling system. This terminal device 100 is equivalent to a vending machine for cigarettes or soft drinks such as juice and functions as an information server. The terminal equipment 100, is connected to an original supplier of a digital signal through a broad band integrated services digital network (B-ISDN) to receive the digital signal as a commodity without specific limitation. As a result of employment of this system, the digital signal is transferred only to a specified terminal device 100 through a communication network in a manner similar to such commodities as cigarettes and juice. In this case, the digital signal as a commodity can be transferred at high speed and in a great amount, free of any traffic jam or air pollution unlike in the case of general commodities. The terminal device 100 is installed in front of a store like a station booth, a cigar stand or a book shop.

The terminal device 100 is roughly comprised of an input section 102, a memory section 103 and an output section 104. Each circuit section, which is

1 connected to a VME bus 105, is adapted to receive  
digital and various control signals. This terminal  
device 100, which is connected to a memory card 101 with  
a reproducing function (hereinafter called "the player")  
5 shown by dotted line in Fig. 1, is used to directly  
receive a specific signal as a commodity.

Fig. 2 is a block diagram showing an input  
section 102 of the terminal device 100. The input  
section 102 of the terminal device 100 has a VME  
10 interface 201 for the broad band integrated services  
digital network (B-ISDN) and an analog input interface  
(right and left analog inputs) for receiving an input  
signal in an analog form. The analog input interfaces  
are provided with low-pass filters 202a, 202b,  
15 associated with the right input Rin and the left input  
Lin, for eliminating extraneous frequency band  
components contained in the analog input signals Rin and  
Lin in advance, respectively. These input signals Rin  
and Lin are alternately selected through a multiplexer  
20 203 with respect to time, introduced to a sample-and-  
hold circuit 204 and converted into a digital signal by  
an analog-to-digital converter 205. At this time, the  
analog-to-digital converter 205 outputs two-channel  
(stereo) time-shared digital signals of right and left  
25 channels in time series, which signals are introduced to  
the VME interface of the input section 207. Such analog  
input interfaces are used for digitalizing and storing  
music programs, regular news, stock market information,

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1 various commodity market situations or the like sent by  
broadcasting in a memory.

A monaural signal is inputted as the above-  
mentioned right or left input signal. The function  
5 may be added to broaden band widths of the low-pass  
filters 202a, 202b for input signals having a broad  
band widths such as music, and to narrow the band widths  
of the low-pass filters 202a, 202b for input signals  
having narrow band widths such as news. Reference  
10 numeral 206 designates an input section controller,  
and numeral 201 a network interface corresponding to  
the B-ISDN.

Each analog input interface may be adapted to  
receive a message from an automatic answering telephone  
15 set by being connected to a telephone line. In such a  
case, the function of a telephone set may be added to  
the terminal device 100 connected with the automatic  
answering telephone set to receive a recorded message  
therefrom. When the analog input interface is used in  
20 this way, the message transfer time is undesirably  
lengthened. If a subscriber to a digital line system  
uses a digital automatic answering telephone set to  
store messages in a digital form, the messages recorded  
can be received in a very short time, and by doing so,  
25 the user can confirm the messages, at the desired time  
while being in transportation means or under the like  
situation.

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1           Fig. 3 is a block diagram showing a structure  
of an embodiment of the memory section in the terminal  
device 100. This memory section includes an external  
memory like a hard disk memory 301, a RAM (random access  
5 memory) 308 as a buffer memory, a ROM (read only memory)  
307 for storing various programs, and a microprocessor  
306 for processing information or performing control  
operations in accordance with these programs. The  
programs include the information-processing program for  
10 a digital or analog input operation, a data exchange  
operation with the hard disk memory 301, a display  
operation of a LCD 303 or a data transfer operation with  
a player 101 connected to the output section. The RAM  
308, though not specifically limited in capacity, has a  
15 storage capacity of approximately 1 MB (megabyte as  
referred to in the same way hereinafter), and the ROM  
307 a storage capacity of approximately 512 KB (kilobyte  
as referred to in the same way hereinafter). The hard  
disk memory 301, though not specifically limited in  
20 capacity, has a storage capacity of approximately 250  
MB, and has a function as a backup memory in case of  
power failure or interception. In addition, it  
functions like a warehouse for storing a great variety  
of digital signals. This hard disk memory 301, which is  
25 connected to an internal bus 309 through a hard disk  
controller 302, is adapted to write and read data in  
response to an instruction from the microprocessor 306.

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In a case of (1) Music, for instance, such music categories as classic, popular and jazz are displayed, so that if a specific music category is selected, a name of a marketable music is displayed. Such music information, though not specifically limited in a storage location, is assumed to be stored in a specific area of the hard disk memory 301 or the ROM 307. When the desired music is not available in the hard disk memory 301, the device 100 is connected to an original supplier of the digital signals through the B-ISDN to transmit an intended music program to the player 101. The LCD 303, which is connected to the internal bus 309 through an LCD controller 304, is used for the above-mentioned display and input operations through the touch keys.

The news, the stock market situation and the like, which are required to be replaced by the latest information as lapse of time, are stored in a buffer memory 403 included in the output section as described later. As a result, the information can be directly transferred to the player 101 without accessing the hard disk memory 301 on each occasion. Also, the music program, if large in sales amount, may be stored in the buffer memory 403. In this case, the top ten items in sales volume of each music category may be displayed as a display menu to facilitate selection by the user.

The monitor 405, though not specifically limited, has a speaker 406 and a headphone output and is used for reproducing a starting part of a given music

1 selected from the music program. This function is one  
like reading a book while standing in bookstore, and is  
effective to promote the sale of the invisible digital  
signal or prevent an error in selection of the digital  
5 signal. The output function of the monitor, though not  
specifically limited, is activated during about ten  
seconds as a maximum time length only when the touch-key  
or the like is turned on. As a result, the monitor  
output is stopped as soon as the object of the selection  
10 is achieved, and therefore the wasted time of monitor  
playback is eliminated. The monitor 405 and the monitor  
controller 404 used in this configuration are equivalent  
to those used in the playback circuit of the player 101  
described later.

15 As explained above, cigarettes and juice sold  
by the vending machine are encased in a package or a  
container integrally therewith. Commercialized in  
formation or the like, on the other hand, are sold by  
use of, as media paper or a floppy disk or an IC memory  
20 functioning as a package or a container. A music  
program is also offered for sale in a form integrated  
together with a storage medium such as magnetic tape or  
compact disk. These media have no commercial value of  
their own. Only in combination with an "electronic  
25 notebook", a personal computer or the like terminal  
device, information is retrievable and processed as a  
commodity. Also, the value of a music program as a

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1 commodity is exhibited only in combination with a  
cassette tape recorder or other reproducing device.

In contrast, according to the present  
invention, a digital signal as a commodity is received  
5 in its own form without any intermediary of a storage  
medium functioning as the container mentioned above.  
For the purpose of receiving of the digital signal, a  
memory circuit 701 is mounted on the player 101 as  
described later. A digital signal introduced to this  
10 memory circuit 701 can be reproduced through a playback  
circuit of the player 101 in unit of player.  
Specifically, the received commodity directly exhibits  
the value thereof as a commodity. These two features  
make the present invention conspicuously different from  
15 the conventional commodity transactions. Further,  
according to a system in which the player 101 is  
connected to the terminal device 100 and in which a  
digital signal is transmitted and received as a  
commodity as described above, only the required  
20 information can be specified and sold when required.

In Fig. 4, numeral 407 designates a power  
supply, which, though not specifically limited, supplies  
power from the terminal device 100 to the player 101 for  
the purpose of transmitting a high-speed digital signal,  
25 i.e., writing operation. Also, in the case where a  
rechargeable secondary battery is used as a power supply  
of the player 101 in place of the primary battery, as  
described later, or in the case where primary and

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- 1 secondary batteries are built in, a digital signal is transferred when the player 101 is connected to the terminal device 100. At the same time, the secondary battery is charged rapidly by the power supply 407.
- 5 Signals transferred between the output section and the player 101 are an operating voltage V, a digital signal D, an address signal A, a control signal C or a status signal S, etc.

Also, in the cassette tape recorders

- 10 commercially available at the present time, the time of information storage is equal to that of reproduction thereof in principle. This provides a great problem to the user in an information vending system proposed by the present invention. In a digital signal transmitting, receiving system, if the convenience of the user is taken into consideration, it is desirable to increase the speed of transfer of a digital signal between the terminal device 100 and the player 101 as far as possible. This function can be realized when a memory, 15 a memory controller and data transfer means which can operate at least more rapidly than the signal to be reproduced, are provided in the buffer memory 403 of the terminal device output section 104 and the memory circuit 701 of the player 101 in Fig. 4.
- 20

- 25 This embodiment will be described with reference to Figs. 5 and 6. First, a block configuration relating to the high-speed transfer on the player 101 side is shown in Fig. 5. The player 101 is added

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1 therein with photo-sensor 502, an I-V amplifier 503, a  
serial-to-parallel converter 504, a PLL oscillator 505,  
a clock divider 506, a multiplexer 507 and a mode switch  
508. In light mode (set when the mode switch 508 is  
5 switched to "light" side), the B inputs of the  
multiplexer 507 are selected to provide Y outputs, and  
therefore external write data supplied as a light pulse  
train (two start bits indicating "1" and "0" states are  
added to the head of the unit write data train) is  
10 written into the memory circuit 701. Specifically, a  
photo-modulated pulse train signal is converted into a  
current signal by the photo-sensor 501, and the waveform  
of the signal is shaped as a voltage signal by the I-V  
amplifier 503. This signal, after being inputted to the  
15 PLL oscillator 505 for extracting the clock components  
from the pulse train signal thus shaped, is also applied  
to the serial signal input terminal D of the serial-to-  
parallel converter 504 at the same time. A signal  
representing the clock components extracted by the PLL  
20 oscillator 505 (8 MHz in frequency according to the  
present invention) acts as a shift clock signal of the  
serial-to-parallel converter 504 and a count clock  
signal of the  $1/n$  ( $n$  represents (the number of quantized  
bits) +2, or 10 according to the present invention)  
25 clock divider 506. An output signal (800 kHz according  
to this embodiment) of the clock divider 506 is a write  
strobe signal for the memory circuit 701.

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1           In electricity mode (set when the mode switch  
is switched to "electricity" side), by contrast, the A  
inputs of the multiplexer 507 are selected to make up Y  
outputs, so that 8-bit parallel data is written into the  
5 memory circuit 701 from the input buffer 501 through the  
multiplexer 507.

Fig. 6 shows a block configuration of a data  
transmitting section of the terminal device 100. The 8-  
bit parallel data is outputted from the output buffer  
10 601 as data of the buffer memory 403, and the data of  
the buffer memory 403 is converted into a serial signal  
by the parallel-to-serial converter 602 to generate a  
signal representing photo-modulated pulse train, and two  
start bits indicating the "1" and "0" states are added  
15 to the head of the pulse train by a start bit adding  
circuit 603. Further, a laser diode 605 is energized by  
the V-I amplifier 604, thereby to output the pulse train  
signal as a photo pulse train signal.

According to this embodiment, information such  
20 as an audio signal can be transferred by photo coupling  
at a high speed in wireless fashion. For example, the  
embodiment under consideration thus makes it possible to  
transfer the audio information of about six minutes (8  
bits in resolution, 22.05 kHz in sampling frequency, and  
25 monaural) only for ten seconds. Also, in the case where  
the frequency of the clock signal is set to 800 kHz for  
reduction of power consumption upon the high-speed

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1 transfer, a satisfactory result is obtained although  
somewhat longer time is required.

5 The basic concept of the present embodiment  
lies in that the contents of a digital memory can be  
directly transferred, taking account for the fact that  
the operating speed of the digital memory such as a  
semiconductor memory is faster than transfer speed of an  
analog signal. Many applications of operation are of  
course possible within the framework of this concept.

10 Apart from the photo-coupling system, for example,  
exactly the same result is obtained by connecting  
directly a data transfer source to a destination by  
connector, or as an alternative, the effect of applica-  
tion of electric wave or magnetism may be used.

15 Further, in a system for transferring 8-bit parallel  
data, although the transmitting or receiving circuits  
simplified and the number of the connector pins is  
increased, the transfer time is decreased further by  
about one order, thereby making it possible to transfer  
20 the above-mentioned data of about six minutes only for  
one second.

Also, although in the present embodiment  
employing a system for directly managing the memory  
circuit 701 of the player 101 by the terminal device  
25 100, the transfer may be started from the first address  
(zero address) of the memory circuit 701 and may be  
ended at the time point of overflow of an address  
counter (such as designated by reference numeral 703 in

Normally, taking the user convenience into account, it is necessary that the required information can be selected from among a wealth of information accumulated in the terminal device 100 and transferred to the player 101 to repeatedly reproduce the required information at a given place and time. Therefore, the storage capacity of the terminal device 100 is at least equal to or larger than that of the player 101. Specifically, assuming that the storage capacity of the player 101 is  $M_p$  and that of the terminal device 100 is  $M_s$ , the relationship  $M_p \leq M_s$  must be held. This condition, however, is not applied to a specific application.

The player 101 is roughly comprised of a large-scale integrated circuit 709 constituted by a gate array, a memory circuit 701, and a playback circuit. The memory circuit 701, though not specifically limited, includes a pseudo-static RAM (PSRAM) having a storage capacity of about 8 MB. As described later, for example, sixteen pseudo-static RAMs of about 4 megabits are mounted to realize the storage capacity of about 8

The address counter 703 generates an address signal for reading the digital signal stored in the memory circuit 701. The multiplexer 702 switches between the address in accessing the memory circuit 701 from the terminal device 100 and the address in accessing the memory circuit 701 inside thereof. More specifically, a digital signal is written into the memory circuit 701 in accordance with the address from the terminal device 100 side, while information is read for playback operation of the particular digital signal in accordance with the address generated from the address counter 703.

20 Numeral 706 designates a low-pass filter including a digital filter circuit for inputting only the band component required for playback to the digital-to-analog converter 707. According to this embodiment, as described later, a digital signal of a plurality of  
25 sampling rates is handled in accordance with the information or program involved. The pass band of the digital filter is switched in accordance with these sampling rates. The digital-to-analog converter has the

1 function of outputting analog signals for the right and  
left channels so separated in accordance with the stereo  
signals inputted in time division. In the case where  
the digital signal is monaural, the same analog signal  
5 is outputted from the two channels. The player 101 is  
adapted to generate an audio output from the headphone  
in order to reduce the weight thereof. Numeral 711  
designates a headphone terminal.

A plan view of an embodiment of the packaging  
10 board configuring the player 101 is shown in Fig. 8.  
The player 101 includes a control board 807 and a memory  
board 802. The control board 807 has mounted along the  
longitudinal ends thereof power supply section with  
button cells 808a to 808d inserted therein and a con-  
15 nector section. The board surface between the power  
supply section and the connector section has mounted  
thereon electronic parts such as semiconductor integ-  
rated circuit devices or the like making up the large-  
scale integrated circuit 709, amplifier devices 805,  
20 806, a low-pass filter 706 and a digital-to-analog  
converter 707. The connector 804 is conforming to the  
JEIDA (Japan Electronic Industry Development Associa-  
tion) standard (a standard for memory card and the  
like). The power supply section includes button cell  
25 holders and can be packaged with four alkali button  
cells (LR44). The size of this control board 807,  
though not specifically limited, is set to 52 mm by 82

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1 mm so as to be accommodatable in the existing IC card case.

The memory board 802 covers the area other than the comparatively thick parts of the connector section and the power supply section of the control board 807, and has mounted eight PSRAMs on each side thereof. The memory board 802 and the control board 807 are connected with each other by a flexible wiring board 803. In other words, the two boards are openable in two direction, right and left, to facilitate inspection and repair.

Fig. 9 shows a side view of the package board as housed in a case. The memory 802 is folded over through the flexible wiring board 803 on the surface area of the control board 807 other than the power supply section and the connector section. As a result, the accommodation in a case equivalent to the existing IC card (RAM card) is made possible, while at the same time realizing a small, thin player 101. Also, since the memory board 802 and the control board 807 can be opened at the time of repair as described above, the electronic parts such as IC and LSI can be easily replaced.

Fig. 10 is a plan view showing another embodiment of the player 101.

In this embodiment, the body of the player 101 and the memory section 1001 are detachable. Specifically, the body of the player 101 includes, as in the case

1 mentioned above, a control board 807 having thereon such  
ICs as a large-scale integrated circuit 709 for control  
operation, a digital-to-analog converter 707 and an  
amplifier 708, a battery case and a memory card  
5 connector 804 based on the JEIDA standard. As shown b  
dotted line in the drawing, there is provided an  
internal space for insertion of the memory section 1001  
(memory card) in the form of thin card and a memory  
section connector 1103 shown in Fig. 11. The memory  
10 section 1001 has a pseudo-static RAM and a backup  
battery housed in a card-like thin plastic case, for  
example, as mentioned above. By making the memory  
section 1001 detachable in this way, a plurality of  
types of memory card are made available. A variety of  
15 RAMs including the static RAM and dynamic RAM or the  
same type of RAM having a plurality of different storage  
capacities may be prepared. Also, in addition to these  
RAMs, the ROM card may be used. Not only the mask-type  
ROM but also EEPROM may be used for receiving digital  
20 signals. In the case where the EEPROM is used, the  
receiving of a digital signal, that is to say, the write  
operation thereof takes a little longer time than when  
the RAM is used. Nevertheless, the use of the backup  
battery is eliminated, thereby simplifying the produc-  
25 tion and handling of the memory card.

Further, the compatibility with the existing  
IC memory card is secured by adapting to the outline of  
the player 101 and the JEIDA standard employed for the

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1 general-purpose IC memory card including the physical  
specifications of the connector, etc., and such  
electrical specifications as the signal characteristics  
and timings and the card attribute information (The  
5 guide line Ver 4.0 is presently standardized). Although  
the outside dimensions, connector, pin arrangement,  
battery voltage, etc. are standardized according to the  
JEIDA standard, the outside dimensions, signal pin  
arrangement and signal characteristics are referred to  
10 specifically in this patent application. Fig. 63 shows  
an outline of the type I card according to the JEIDA  
standard. The outside dimensions of this card are

85.6 mm x 54.0 mm x 3.3 mm

Fig. 64 shows an outline of the type II card according  
to the JEIDA standard. The outside dimensions of this  
15 card are

85.6 mm x 54.0 mm x 5.5 mm

(3.3 mm for the connector section). Fig. 65 shows a  
signal pin arrangement, in which the number of pins is  
68 for the guide line Ver 4.0. A signal characteristic  
is shown in Fig. 66.

20 Fig. 11 is a block diagram showing an  
embodiment of the body of the player 101 and the memory  
section 1001.

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1           A memory card connector 804 based on the JEIDA  
standard to be connected with the terminal device 100 as  
described above is arranged on the outside of the body  
of the player 101. The player 101 has a memory section  
5 connector 1103 built therein. The card-like memory  
section 1001 is detachable through these memory section  
connectors 102, 1103.

          The data inputted from the memory card  
connector 804 corresponding to the terminal device 100  
10 is supplied to a data input terminal Di of the memory  
section 1001 through the memory section connectors 1002,  
1103. The address inputted from the memory card  
connector corresponding to the terminal device 100 is  
supplied to an input A of the multiplexer 1105. The  
15 other input B of the multiplexer 1105 is supplied with a  
playback address as a memory address for playback  
generated by the address counter 1106 at the inside of  
the player 101. The address for receiving of a digital  
signal or the playback address is selectively supplied  
20 to the address terminal A of the memory section 1001  
through the multiplexer 1105. The control signal  
inputted from the memory card connector 804 correspond-  
ing to the terminal device 100 is supplied to the input  
A of the multiplexer 1104. The other input B of the  
25 multiplexer 1104 is supplied with a playback control  
signal generated by the controller 1101 of the body of  
the player 101. The control signal for receiving of the  
digital and the playback control signal is selectively

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1 supplied to the control terminal C of the memory section  
1001 through the multiplexer 1104.

In the manner mentioned above, the multi-  
plexers 1105, 1104 are provided for switching the  
5 addresses or the control signals so as to selectively  
perform one of the receiving of the digital signal in  
accessing the memory section 1001 from the terminal  
device 100 side and the playback of the digital signal  
in accessing through the address counter 1106 or  
10 controller 1101 at the inside of the player 101. In  
this playback operation, the digital signal outputted  
from the output terminal Do upon the read operation of  
the memory section 1001 is outputted as an audio signal  
through the memory section connectors 1002, 1003 and a  
15 playback circuit including the low-pass filter 706, the  
digital-to-analog converter 707 and the amplifier 708 at  
the inside of the player 101.

The controller 1101 at the inside of the  
player 101 is adapted to control the digital-to-analog  
20 converter 707 and the low-pass filter 706 mentioned  
above in accordance with the ID code or the like of the  
reproduced digital signal.

The power supplied from the terminal device  
100, on the other hand, is used also as an operating  
25 voltage for high-speed writing of the digital signal  
into the memory section 1001 connected through the  
memory sections 1002, 1103, or for rapid battery-  
charging operation in the case where the batteries 808a

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1 to 808d and mounted inside of the player 101 as the  
secondary batteries.

A block diagram of an embodiment of the power  
supply system for the player 101 is shown in Fig. 12.

5 The player 101, as described above, is comprised of a  
memory circuit 701, a controller 704 made up of a  
digital circuit, a digital filter 706, a digital-to-  
analog converter 707 and an amplifier 708 for outputting  
an analog signal. Each of these circuit blocks has a  
10 different operating voltage. The memory circuit 701,  
for instance, requires a comparatively high operating  
voltage of about 4 V when a pseudo-static RAM is used as  
mentioned above. In contrast, the use of a CMOS circuit  
gate array or the like in a digital circuit makes  
15 possible an operation at a comparatively low voltage of  
about 3 V. The amplifier circuit 708 for driving the  
headphone is operable even at a lower operating voltage  
of about 1.5 V. As a result, except for the memory  
circuit 701, which is supplied steadily with a voltage  
20 from the battery 1203, for holding information, the  
voltages of the batteries 1204 and 1205 are supplied to  
each corresponding circuit through the power switches  
1206 and 1207 by use of the batteries 1203, 1204 and  
1205 adapted for the operating voltages of the  
25 respective circuits.

In this way, the battery life is lengthened by  
supplying power to the directly associated circuits by  
use of a plurality of types of batteries having

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1 different voltage values. If the internal power supply  
is set to the highest voltage of 4 V, for instance, a  
wasteful current flows in the digital or analog circuit,  
thereby to increase the current consumption. If the  
5 voltage of 4 V is supplied through an internal voltage  
drop circuit, the current consumption in the voltage  
drop circuit would shorten the battery life. According  
to the present embodiment, in contrast, power is  
supplied through a selected battery having the required  
10 minimum capacity for each circuit, and therefore the  
wasteful current consumption is decreased, thereby  
substantially lengthening the battery life.

If the writing of a digital signal into the  
memory circuit 701 or the reading of a digital signal  
15 therefrom is to be speeded up, the operating current of  
the memory circuit 701 must be increased. For this  
purpose, the terminal device 100 is provided with power  
supplying connectors for supplying an operating voltage  
of about 5 V higher than the internal voltage. In this  
20 case, in order to automatically switch the power between  
the player 101 and the terminal device 100 sides, the  
connector 804 and the battery 1203 are used to supply a  
voltage to the power terminal of the memory circuit 701  
through diodes 1201 and 1202, respectively. In this  
25 configuration, once the player 101 is connected to the  
terminal device 100, the diode 1201 is turned on since  
the operating voltage of the terminal device 100 is  
about 5 V and higher than the voltage of about 4 V

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1 across the battery 1203, and the memory circuit 701 is  
operated by the operating voltage from the terminal  
device 100 side. At the same time, the diode 1202 on  
the battery 1203 side is reversely biased into an off  
5 state with the result that no reverse current flows from  
the connector of the terminal device 100 to the battery  
1203. When the player 101 is pulled off from the  
connector of the terminal device 100, the connector is  
opened and therefore the diode 1202 is opened, thereby  
10 supplying the voltage across the battery 1203 to the  
memory circuit 701. By employing a power supply system  
of this type, the data transfer from the terminal device  
100 to the memory circuit 701 can be effected at a high  
speed, while lengthening the battery life of the player  
15 101 at the same time.

Fig. 13 shows a format of a digital signal  
transferred from the terminal device 100 to the player  
101 in the present embodiment.

As some sources of digital signals, a music  
20 program requires a broad frequency band and news does  
not require such a broad frequency band. In other view  
points, stereo signal reproduction is required or  
monaural signal reproduction is sufficient. In this  
way, the limited storage capacity of the memory circuit  
25 701 built in the player 101 needs to be utilized  
effectively in accordance with the source, so that a  
sampling rate, bit length and stereo/monaural mode of a  
digital signal can be selected depending on the source.

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1 This requires the setting of the playback conditions  
corresponding to each source. In this case, if manual  
selection is attempted, display means used for designat-  
ing the selection would be added, with the result that  
5 the operation by an unaccustomed user would extremely  
deteriorate the sound quality or make playback impos-  
sible because of mismatch of the playback conditions  
against the source.

In order to solve this problem, an ID code  
10 1308 for designating the playback conditions is inserted  
in the head of a digital signal as shown in Fig. 13.  
This ID code is followed by a data including a digital  
signal to be reproduced. In this way, a digital signal  
and the ID code for designating the playback conditions  
15 are received to the player 101 as an integral signal.  
As a result, the ID code 1308 and the digital signal are  
integrally stored in the memory circuit 701 of the  
player 101. In the case of employing a system for  
transferring the ID code 1308 separately from the  
20 digital signal to the player 101, some idea would be  
needed to prevent disappearance of the ID code 1308 when  
the power for the player 101 is interrupted. This  
problem, however, is not posed when the digital signal  
is stored integrally in the memory circuit 701 as  
25 described according to the present embodiment.

A block diagram of an embodiment of the player  
101 corresponding to a digital signal into which the ID  
code 1308 is inserted is shown in Fig. 14.

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Also, the code 1302 (D2) is inputted to a bit length converter 1405. The bit length converter 1405 has the function of parallel-to-serial conversion and inputs to a low-pass filter 706 a digital signal outputted from the memory circuit 701 in maximum units of two bytes in accordance with the bit length designated by 1302 (D2). The low-pass filter 706, including a digital filter, receives a clock pulse corresponding to the sampling rate from the controller 704 and cuts an extraneous frequency band of the input digital signal. Also, the digital-to-analog converter 707 converts an input digital signal into an analog signal in response to a clock pulse corresponding to the sampling rate from the controller 704. The amplifier 708 is for amplifying the analog signal thus converted thereby to form a drive signal such as for headphone.

1 Although not shown in the drawing, the output section of  
the digital-to-analog converter 707 has a low-pass  
filter including a resistor and a capacitor.

The ID code 1308, though not specifically  
5 limited, includes eight bits of 1300 to 1307 (D0 to D7),  
of which 1300, 1301 (D0 and D1) are used to designate  
four sampling frequencies. The frequency 5.5125 kHz is  
designated when 1300 and 1301 are 00, 11.025 kHz when  
1300 and 1301 are 01, 22.05 kHz when 1300 and 1301 are  
10 10, and 44.1 kHz when 1300 and 1301 are 11. 1302 is  
used for designating the resolution. Eight bits are  
designated when it is 0, and 16 bits when it is 1. On  
the other hand, 1303 (D3) is used for mode designation,  
setting "monaural" when it is 0 and "stereo" when it is  
15 1. The remaining four bits 1304 to 1307 (D4 to D7) are  
reserved for extension.

The relationship between the memory capacity  
(total number M of bits) of the memory circuit 701, the  
bit length N as a resolution, the sampling rate  $f_s$ , the  
20 mode S (assuming that stereo  $S = 2$  for stereo mode, and  
 $S = 1$  for monaural mode) and the recording/playback time  
t is expressed by equation (1) below.

$$t = M / (N \times f_s \times S) \quad \dots\dots (1)$$

As the sampling rate mentioned above, though  
not specifically limited, 44.1 kHz is used for playback  
25 of an ultra HiFi music program equivalent to the compact

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1 disk player, 22.05 kHz for playback of a HiFi music  
program, 11.024 kHz for playback of an information  
program such as news, and 5.5125 kHz for playback of an  
automatic answering telephone set, or the like. As  
5 described above, if the sampling frequency is set in  
units of double, the player 101 may form one reference  
frequency corresponding to say, 44.1 kHz, and by divid-  
ing it in units of 1/2, can easily form the sampling  
frequency. As a consequence, the recording/playback  
10 time is lengthened in reverse proportion to the four  
sampling frequencies  $f_s$  described above. In other  
words, if a predetermined recording/playback time is to  
be obtained, the storage capacity is increased in  
proportion to the sampling rate  $f_s$ .

15 In the case where the bit length is increased  
from 8 to 16 bits, the recording/playback time is  
doubled as will be seen from equation (1) above. With  
the increase in bit length, a double storage capacity is  
required of the memory circuit 701 to meet the increase.  
20 If the bit length is reduced to 8 bits, by contrast, the  
recording/playback time is increased to double for the  
same storage capacity. In stereo mode, specifically, a  
double data is required as compared with when the system  
is in monaural mode. More specifically, in stereo mode  
25 when right and left signals are outputted alternately  
from the memory circuit 701, the required storage  
capacity doubles from that required in monaural mode.

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1           According to this embodiment, the three  
          playback conditions including sampling rate, bit length  
          and mode are set for a digital signal source as  
          described above, and are combined as desired to permit  
5   playback, whereby the limited storage capacity of the  
          memory can be utilized to the maximum efficiency. The  
          playback conditions which can be combined in a great  
          variety can be automatically set in the player 101 by  
          the use of the ID code 1308, and therefore any user can  
10   easily reproduce the information received without any  
          operating inconvenience.

          The type or frequency of the sampling rate can  
          be set as desired. In such a case, an arrangement  
          should be made to generate a clock pulse in accordance  
15   with each sampling rate. Also, the ID code 1308 may  
          have added thereto a bit that can be designated by the  
          operation of a terminal device. By setting the slow or  
          fast playback mode automatically by means of the  
          remaining bits as explained later, for example, a  
20   playback mode such as reproduction by program or  
          continuous reproduction for the whole program may be  
          designated automatically.

          Fig. 15 is a circuit diagram showing an  
          embodiment of a quantizing noise remover.

25           When an analog signal is quantized, a quantiz-  
          ing noise (error component) is always generated. This  
          quantizing noise is offensive to the ear especially  
          during a voice interval. According to the present

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1 embodiment, a quantizing noise remover as described  
below is inserted in the input of the digital-to-analog  
converter 707.

5 The digital signal read out of the memory  
circuit 701 is inputted to the digital-to-analog  
converter 707 and is converted into an analog signal  
Vout. The quantizing noise remover according to the  
present embodiment, though not specifically limited, is  
intended for a case in which a digital signal is  
10 comprised of a 2' complement binary code. The digital  
signal including D0 to Dn read out of the memory circuit  
701 is inputted to the corresponding input terminals D0  
to Dn of the digital-to-analog converter 707 through the  
AND gates 1510 to 151n respectively. The digital signal  
15 read out of the memory circuit 701 is inputted to a  
level checker 1507 for checking a level where the signal  
is considered to represent a voice interval. The output  
signal which has been considered to represent a voice  
interval by this level checker 1507 is inputted to a  
20 timer 1508 shown by dotted line in the same drawing for  
time judgement. If the level considered to represent a  
voice interval by the level checker 1507 and the timer  
1508 continues for a predetermined time length, the  
particular period is decided to be a voice interval, so  
25 that the output from an inverter 1505 becomes a logic  
zero, thereby controlling the system to close the AND  
gates 1510 to 151n. Specifically, the AND gates 1510 to  
151n forcibly set the signals D0 to Dn inputted to the

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1 digital-to-analog converter 707 to logic 0 by the logic  
0 of the output signal of the inverter 1505 without  
regard to the digital signal read out of the memory  
circuit 701.

5           The digital signals D0 to Dn are comprised of  
2' complement binary codes as explained above. More  
specifically, when D0 to Dn are eight bits, the positive  
maximum value takes 01111111 and the negative maximum  
value 10000000, with the "0" level as 00000000. +1 in  
10 decimal notation is equivalent to 00000001 in binary  
notation. Once a time period is considered to be a  
voice interval as described above, therefore, the output  
of the AND gates 1510 to 151n is fixed to zero, thereby  
making it possible to remove the quantizing noise  
15 completely during a voice interval.

          The level checker 1507 in Fig. 15 is adapted  
to set a positive maximum value  $+\Delta L$  and a negative  
maximum value  $-\Delta L$  considered to represent a voice  
interval. When +1 is assumed to be a positive maximum  
20 value  $+\Delta L$ , for example, the input B of the comparator  
1501 takes the form of 00000001, while when -1 is  
assumed to be a negative maximum value  $-\Delta L$ , the input B  
of the comparator 1509 is given as 11111111. The input  
A of the comparators 1501, 1509 is supplied with a  
25 digital signal from the memory circuit 701. A "1"  
output signal is formed by the comparator 1501 when  $A \leq$   
B, and by the comparator 1509 when  $A \geq B$ . The output  
signals of these comparators 1501 and 1509 are outputted

00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000

1 through the AND gate 1502. As a result, the output of  
the AND gate 1502 is "1" detecting a voice interval when  
the digital signal is 00000001, 00000000 or 11111111.

When the digital signal is 00000010 or  
5 otherwise larger than  $+\Delta L$ , the output of the comparator  
1501 is "0", while when the digital signal is 11111110  
or otherwise smaller than  $-\Delta L$ , the output of the  
comparator 1509 is "0". As a consequence, the AND gate  
1502 forms a "1" output signal only when the digital  
10 signal is included within a range considered to  
represent a voice interval.

The timer 1508 includes a counter 1503 and a  
comparator 1504. The reset input  $\bar{R}$  of the counter 1503  
is supplied with a detection output of the level checker  
15 1507. When a voice interval is judged to be involved,  
the reset state of the counter 1503 is cancelled, and  
therefore the counting operation of the clock pulses CK  
is started by the counter 1503. The count output of the  
counter 1503 is supplied to the input A of the compa-  
20 rator 1504. The input B of the comparator 1504 is  
supplied with a set time  $t$  for regarding a given period  
as a voice interval. As a result, the comparator 1504  
outputs a "1" signal ( $A \geq B$ ) when the voice interval  
level exceeds the set time  $t$ . This output signal is  
25 inverted at the inverter 1505 and is inputted to the AND  
gates 1510 to 151n, and therefore regardless of the  
digital signal read out of the memory circuit 701, the

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1 digital signal supplied to the input of the digital-to-analog converter 707 assumes a "0" level of 00000000.

When the level checker 1507 is supplied with a level of a digital signal exceeding  $+\Delta L$ , the comparator  
5 1501 or 1509 detects the fact, and reduces the output to "0", thereby resetting the counter 1503 of the timer 1508. As a result, the output signal of the comparator 1504 of the timer 1508 becomes "0", so that the control input of the AND gates 1510 to 151n is set to "1"  
10 through the inverter 1505. The input of the digital-to-analog converter 707 is thus supplied with a digital signal read out of the memory circuit 701. In this manner, immediately after the end of a voice interval, the digital signal read out of the memory circuit 701 is  
15 converted into an analog signal.

The result of an experiment conducted by the inventor shows that the set time  $t$  of the timer 1508 is generally desirably in the range from 0.5 ms to 20 ms depending on the contents of the music or news program  
20 involved. This range may of course be exceeded to some degree in setting a time without any problem. Also, the level considered to be a voice interval may be switchable in accordance with the input source or the related resolution. In the case of a 16-bit digital signal, for  
25 example, it is generally desirable to set a wider range than in the case of a 8-bit digital signal. Also, the digital signal of 2' complement binary code need not be used, so that in the case of 8-bit digital signal,

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1 01111111 or 10000000 may be set at an AC-like neutral  
level. In the case of such a digital signal, the  
digital signal from the memory circuit 701 may be  
replaced by a selection of 01111111 or 10000000 if a  
5 voice interval is detected by a combination of a  
multiplexer and a gate circuit.

Waveforms for explaining the operation  
mentioned above are shown in Fig. 16. The waveform 160a  
in the drawing represents a case in which the digital  
10 signal from the memory circuit 701 is directly inputted  
to the digital-to-analog converter to form an analog  
signal. As shown in Fig. 16, the signal undergoes a  
change in accordance with the quantizing error during a  
voice interval, thus generating a noise cacophonous to  
15 the ear. In the quantizing noise remover according to  
the present embodiment, in contrast, as shown by 1600b  
in Fig. 16, upon the lapse of a predetermined time  $t$   
considered to be a voice interval, a digital signal  
corresponding to "0" level is forcibly subjected to  
20 digital-to-analog conversion by the AND gates 1510 to  
151n, and therefore the above-mentioned noise continues  
to be outputted until the arrival of the next "0"-level  
audio signal free of the noise. The predetermined time  
length  $t$  is very short and ranges from about 0.5 ms to  
25 20 ms, and therefore the quantizing noise generated  
during this period is not offensive to the ear.

The quantizing noise remover 1500 according to  
the present embodiment is not only used with the player

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1 101 as described above but also finds wide applications  
as various digital audio processors such as a digital  
audio tape recorder processing a digital audio signal.

Fig. 17 is a circuit diagram showing an  
5 embodiment of a security circuit used with a digital  
signal selling system according to the present  
invention.

In selling an audio signal, etc. in digital  
form as a commodity, it is important to prevent it from  
10 being easily duplicated in order to improve the  
commercial value thereof. For this purpose, a first  
method is to add the function of permitting only a  
specified person to perform the substantial playback  
operation of the digital signal. In a second method,  
15 upon transfer to the player 101 of a digital signal sold  
in the digital signal selling system according to the  
above-mentioned embodiment, the signal conversion  
described below is effected within the player 101 as a  
function to prevent read duplication.

20 In order to permit only a specified person to  
perform the playback operation or to duplicate, the read  
output section of the memory circuit 701 is provided  
with EOR gates 1700 to 170n controlled by a password  
check signal. These EOR gates 1700 to 170n may be  
25 either provided as parts corresponding to all bits of  
the read signals D0 to Dn or only for one or a plurality  
of bits including at least the most significant bit with  
equal effect.

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1           The input data terminal of the memory circuit  
701 is supplied directly with a digital signal trans-  
ferred from the terminal device 100 (information  
server). In the case of using a semiconductor memory  
5 with the input and output of the memory circuit 701  
shared with each other, the EOR gates 1700 to 170n are  
inserted in the read signal route of the signal bus  
connecting the data terminal of the memory. The digital  
signal is read out of the memory circuit 701 by an  
10 address signal generated by the address counter 702  
receiving an address update pulse.

          The password described above is set in advance  
in the player 101 by a switch, ROM, etc. This password  
is notified to the purchaser at the time of purchase of  
15 the player 101 by him. As a result, the password is set  
at the time of reproducing the digital signal by the  
player 101. When the password registered by a comparator  
or the like not shown coincides with the password  
inputted, a password judging signal is reduced to "0".  
20 The EOR gates thus output a "0" coincidence signal when  
"0" coinciding with "0" is inputted thereto. When "1"  
signal not coincidental with "0" is inputted, on the  
other hand, a "1" noncoincidence signal is outputted.  
In this way, when the password judging signal is "0",  
25 the EOR gates 1700 to 170n output an input digital  
signal in its direct form.

          When it is judged by a comparator, etc. not  
shown that a registered password fails to coincide with

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1 the input password, by contrast, the password judging  
signal of "1" is outputted. As a result, the EOR gates  
output a "0" coincidence signal when a "1" signal  
coinciding with "1" is inputted thereto, and a "1"  
5 noncoincidence signal when "0" not coinciding with "1"  
is inputted thereto. In this fashion, when the password  
judging signal is "1", the EOR gates 1700 to 170n output  
an input digital signal in an inverted form. When the  
EOR gates 1700 to 170n are inserted for the digital  
10 signals of all the bits as explained above, all the bits  
are inverted when the passwords fail to coincide with  
each other, so that the resulting audio signal with  
inverted bits, which is meaningless if converted into an  
analog signal, assures the confidentiality of informa-  
15 tion. Also, a password is required even when taking a  
copy, or, in other words, even when the data is out-  
putted outside from the memory circuit 701, thus  
preventing an easy duplication.

Some information such as news or traffic data  
20 are too small in importance to protect. In such a case,  
the password may be made null and void by use of the ID  
code 1308 mentioned above. In other words, the system  
may be arranged to perform the above-mentioned security  
operation on condition of coincidence of the password,  
25 only when information protection is required by the ID  
code 1308. By doing so, the seller may designate an  
item requiring security. Also, a call received by the  
automatic answering telephone set may be of such a

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1 nature that one wants to keep it private. In such a  
case, an arrangement may be made to designate security  
mode by the ID code 1308 to assure protection by the  
terminal device 100. In any way, the operating trouble  
5 is minimized by making such an arrangement as to require  
a password input only when true information protection  
is assured by the ID code 1308.

Fig. 18 is a circuit diagram showing another  
embodiment of the security circuit used with the digital  
10 signal selling system according to this embodiment.  
According to this embodiment, a security circuit using a  
password coincidence signal and EOR gates 1800 to 180n  
is inserted in the data input terminal side of the  
memory circuit 701. Also in this case, when the  
15 passwords are not coincident, each bit or one or a given  
number of bits of the digital signal written in the  
memory circuit 701 are inverted and converted into a  
meaningless audio signal, thus assuring the confiden-  
tiality as in the aforementioned case. In this case, at  
20 the time of transfer of the digital signal requiring  
security from the terminal device 100, a data is  
transferred substantially effectively only when a  
password is inputted and is coincidental by the  
operation of touch keys or the terminal device 100,  
25 while if the password is incoincident, the bits are  
inverted as mentioned above, thereby transferring a  
substantially meaningless digital signal. As an

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1 alternative, the transfer operation itself may be  
suspended.

Fig. 19 is a circuit diagram showing another  
embodiment of the security circuit used with a digital  
5 signal selling system according to the present inven-  
tion. In this embodiment, a security circuit using a  
password coincidence signal and EOR gates 1900 to 190m  
is inserted in the address input side of the memory  
circuit 701. In this case, when the password is  
10 incoincident, unlike in the case of inputting an address  
selection of the memory circuit 701, one or a plurality  
of bits are inverted, whereby the addresses are  
discontinuous but not continuous unlike for input. As a  
result, the digital signal read by such discontinuous  
15 addresses is meaningless as audio information any  
longer, thereby making information protection possible  
in this case as in the previous case.

The embodiment of Fig. 17 or Fig. 18 may be  
combined with that of Fig. 19 to configure a security  
20 circuit including one or a plurality of EOR gates for  
data and address respectively. In this way, the  
combination of data and the related address makes  
tighter information protection possible.

Fig. 20 is a circuit diagram showing a further  
25 embodiment of the security circuit used with a digital  
signal selling system according to the present inven-  
tion. This embodiment is mainly aimed at preventing  
duplication of a digital signal. The player 101 has

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1 passwords registered therein by EPROM or the like.  
These passwords are codes not notified even to the  
purchaser of the player 101.

Each bit of these codes is supplied to one of  
5 the inputs of the EOR gates 2000 to 200n, 2010 to 201n  
inserted in the input and output of the memory circuit  
701. In Fig. 20, an EOR gate is provided for all the  
bits of the data input and output of the memory circuit  
701. Instead, the EOR gates 2000 to 200n, 2010 to 201n  
10 may be inserted for only a given one or a plurality of  
bits. Each corresponding input and output, however, are  
provided as a pair with EOR gates 2000 to 200n, 2010 to  
201n respectively.

The data input bit for which the input of the  
15 ROR gates 2000 to 200n, 2010 to 201n have been reduced  
to "0" by the above-mentioned password is written  
directly, while the data input bit for which the input  
of the EOR gates 2000 to 200n, 2010 to 201n has been  
made "1" by the above-mentioned password is written in  
20 inverted form.

The digital signal read out of the memory  
circuit 701 is applied through the EOR gates 2000 to  
200n, 2010 to 201n controlled by the above-mentioned  
same password, whereby the through bits remain through  
25 bits, while inverted bits are inverted again into the  
original form. As a result, the same digital signal as  
an input digital signal is transmitted to the digital-

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1 to-analog converter 707, thereby posing no problem in  
audio playback.

In contrast, the reading itself of the memory  
circuit 701 is outputted to the connector side. In  
5 other words, a digital signal bit-converted by the  
password is outputted on the write circuit side. As a  
result, a copied digital signal, unlike the original  
digital signal, becomes a meaningless one, and therefore  
the duplication is substantially prevented. By the way,  
10 the password may be comparatively easily decoded by any  
person having the knowledge of digital circuits. In  
view of the selling price of the news, stock market news  
or the music program mentioned above, however, the labor  
required for destroying the security would be higher and  
15 more meaningless. Specifically, the security in the  
digital signal selling system according to this  
invention is sufficient if an easy duplication or  
eavesdropping can be prevented.

Fig. 21 is a circuit diagram showing still  
20 another embodiment of the security circuit used with the  
digital signal selling system according to the present  
invention. In this embodiment, instead of the EOR gates  
for passing a signal in direct or inverted form, a bit-  
rearranging circuit 2101 is used. The bit-rearranging  
25 circuit 2101 has two signal routes, one for outputting  
an input signal in its direct form, and the other for  
spatially exchanging the output-side bits D0 to Dn for  
the input-side bits D0 to Dn. Specifically, the least

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1 significant bit D0 is outputted as the most significant  
bit Dn, or D1 is outputted as D2. If the password  
judging signal is incoincident, this bit-rearranging  
circuit enables a digital signal to be outputted with  
5 meaningless ones destroyed. This bit-rearranging  
circuit 2101 may be inserted on the input-side data in  
place of the EOR gates shown in Fig. 18, or on the  
address input side in place of the EOR gates shown in  
Fig. 19.

10 Fig. 22 is a specific circuit diagram showing  
an embodiment of the bit-rearranging circuit 2101 used  
with the above-mentioned security circuit.

In Fig. 22, a bit-rearranging circuit for one  
bit is illustratively shown for a digital signal  
15 including a plurality of bits.

One of input digital signals of a plurality of  
bits including D0 to Dn is selected by a selector 2201  
and outputted as the least significant bit D0 from the  
output terminal. The selector 2201 selects and outputs  
20 one of the signals D0 to Dn by a selection signal formed  
by a decoder 2202.

In the case where the digital signals D0 to Dn  
are eight bits, a random number generator 2204 generates  
a 3-bit random number (0 to 7 in decimal notation),  
25 which is supplied to the input terminal B of the multi-  
plexer 2203. The other input terminal A of the multi-  
plexer 2203 is supplied with a 3-bit binary signal (000)  
designating the decimal zero corresponding to the output

00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000

1 bit D0. The selection terminal S of the multiplexer  
2203 is supplied with a password judging signal. The  
password judging signal becomes a logic zero when the  
password is coincidental, so that the signal of the  
5 input A of the multiplexer 2203 is sent from the  
output Y.

As described above, when the password is coincidental, the decimal zero corresponding to the output bit D0 is inputted to the decoder 2202 through the multiplexer 2203, and therefore a selection signal of the input bit D0 is formed and supplied to the selector 2201 by the decoder 2202. When the password is incoincident, on the other hand, the 3-bit signal generated by the random number generator 2204 is selected and inputted to the decoder 2202. As a result, the decoder 2202 decodes a 3-bit signal and forms one selection signal from the 8-bit input signals D0 to Dn. The probability of the input signal D0 being selected is 1/8. since a similar circuit is provided also for the remaining 7-bit output signals, the probability of the input signals D0 to Dn being outputted in their direct form even when the password is incoincident is as small as  $1/(8 \times 8 \times 8 \times 8 \times 8 \times 8 \times 8 \times 8) = 1/16777216$ , thus making information protection possible. The feature of this circuit lies in that since the random number generator 2204 makes the combination of bit exchange different in each case, it is substantially

1 impossible to decode true data from the bit train  
outputted.

Now, explanation will be made about an embodiment of the function of preventing the digital signal stored in the memory circuit 701 of the player 101 from being read rightly from outside. Normally, the data terminal (D in Fig. 4) of the player 101 has the input and output thereof shared with each other. And an output enable signal is supplied for keeping the data terminal in output state. In other words, although the logic level is not specifically limited, the player 101 has the data terminal thereof kept in output state only when the output enable signal is valid (logic "1" according to the present invention). As a result, the duplication preventing circuit is inserted, though not specifically limited, in the part related to the data read route.

Fig. 23 is a circuit diagram showing an embodiment of the security circuit suitable for duplication prevention used with a digital signal selling system according to the present invention. In order to allow a specified person to duplicate, the read output section of the memory circuit 701 has an AND gate 2301 for controlling an output enable signal OE by a password judging signal and buffers 23000 to 2300n with the outputs thereof controlled by the output enable signal OE. These buffers 23000 to 2300n are adapted to maintain the outputs thereof in high impedance state as

5           The input data terminal of the memory circuit  
701 is supplied directly with a digital signal trans-  
ferred from the terminal device 100. In the case of  
using a semiconductor memory with the input and output  
of the memory circuit 701 shared with each other, the  
10 buffers 23000 to 2300n are inserted on the read signal  
route of the signal bus connected with the data terminal  
of the memory circuit. A digital signal is read from  
the memory circuit 701 by an address signal generated by  
the address counter 703 not shown. Also, the output  
15 enable signal OE is inputted to the AND gate 2301  
together with a password judging signal, which is  
controlled by the password judging signal inverted by  
the inverter 2302.

This password is set in advance in the player 101 by switch, ROM, etc., and is notified to the purchaser at the time of purchase of the player 101. As a result, when a stored digital signal is read out by the player 101, the above-mentioned password is set. When a password registered by a comparator, etc. not shown coincides with an inputted password, the password judging signal is reduced to logic "0", and after being inverted in the inverter 2302, is inputted to the AND gate 2301. Thus the AND gate 2301 outputs a logic "0"

In contrast, when the password registered by a comparator, etc. not shown is judged to coincide with the inputted one, the password judging signal is made logic "1", and after being inverted in the inverter

Fig. 24 is a circuit diagram showing another embodiment of the security circuit suitable for duplication prevention used with a digital signal selling system according to the present invention. In this embodiment, the read output section of the memory circuit 701 has AND gates 24010 to 2401n for controlling the output of the memory circuit 701 by a password judging signal and buffers 24000 to 2400n with the output thereof controlled by the output enable signal OE. Also in this case, duplication is prevented as in

1 the previous case by a password no-coincidence signal.  
From this embodiment involving one or a given number of  
bits of data, it is easily understandable that the AND  
gates may be replaced with equal effect by OR gates or  
5 EOR gates.

Fig. 25 is a circuit diagram showing still  
another embodiment of the security circuit suitable for  
duplication prevention used with a digital signal  
selling system according to the present invention. This  
10 embodiment has a security circuit using a password  
coincidence signal and AND gates 25000 to 2500m on the  
address input terminal side of the memory circuit 701.  
When the password is not coincident, unlike in the case  
where the address selection of the memory circuit 701  
15 makes up an input, one or a plurality of bits are fixed  
to logic "0", and therefore a continuous address at the  
input is changed to a discontinuous one at the output.  
The digital signal read by this discontinuous address is  
meaningless and not right information any longer, thus  
20 making it possible to protect information as in the  
previous case. According to this embodiment, as in the  
embodiment shown in Fig 24, one or a given number of  
bits of the address input are involved, and therefore it  
is easily understood that the AND gates may be replaced  
25 by OR or EOR gates with equal effect.

Fig. 26 is a circuit diagram showing a still  
further embodiment of the security circuit suitable for  
duplication prevention used with a digital signal

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1 selling system according to the present invention. In  
this embodiment, a bit-rearranging circuit 2101 is used  
as in the embodiment of Fig. 21 in place of the means  
for controlling bits by an AND gate mentioned above. A  
5 typical bit-rearranging circuit has two signal routes,  
one for outputting an input signal in its own form, and  
the other for spatially replacing the input bits D0 to  
Dn with the output side bits D0 to Dn, or more  
specifically, for outputting the least significant bit  
10 D0 as the most significant bit Dn, or D1 as D2. If the  
password judging signal indicates no-coincidence, this  
bit-rearranging circuit enables a digital signal to be  
destroyed and outputted in meaningless form.

Fig. 27 is a specific circuit diagram showing  
15 an embodiment of the bit-rearranging circuit 2101  
similar to the one shown in Fig. 22 used with the  
security circuit described above.

A one-bit-rearranging circuit for a digital  
signal having a plurality of bits is shown as a typical  
20 example in Fig. 27.

A digital signal of a plurality of bits  
including D0 to Dn is inputted to a selector 2201 where  
one of them is selected and outputted as the least  
significant bit D0 from the output terminal. The  
25 selector 2201 selects and outputs one of the bits D0 to  
Dn by a selection signal formed by the decoder 2202.

In the case where the digital signals D0 to Dn  
are eight bits, the random number generator 2204

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1 generates a 3-bit random number (0 to 7 in decimal  
notation), and supplies it to the input terminal B of  
the multiplexer 2203. The other input terminal A of the  
multiplexer 2204 is supplied with a 3-bit binary signal  
5 (000) for designating a decimal 0 corresponding to the  
output bit D0. The selection terminal S of the  
multiplexer 2203, on the other hand, is supplied with a  
password judging signal. The password judging signal is  
reduced to logic "0" and causes the signal of the input  
10 A of the multiplexer 2203 to be transmitted from the  
output Y when the password is coincident.

When the password is coincident as mentioned  
above, the decimal 0 corresponding to the output bit D0  
is inputted to the decoder 2202 through the multiplexer  
15 2203, and therefore the decoder 2202 forms and supplies  
a selection signal of the input bit D0 to the selector  
2201. As a result, the selector 2201 outputs an output  
signal D0 in the same form as the input signal D0. When  
the password is not coincident, by contrast, a 3-bit  
20 signal generated by the random number generator 2204 is  
selected and inputted to the decoder 2202. The decoder  
2202 thus decodes the 3-bit signal and forms one selec-  
tion signal out of the 8-bit input signals D0 to Dn.  
The probability of the input signal D0 being selected is  
25 1/8. A similar circuit is provided also for the remain-  
ing 7-bit output signals, so that the probability of the  
input signals D0 to Dn being outputted in their own form  
even when the password is not coincident is  $1/(8 \times 8 \times 8)$

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1     $x 8 \times 8 \times 8 \times 8 \times 8 \times 8) = 1/16777216$ , which is sufficiently  
low to protect confidential information. The feature of  
this circuit lies in that since bit exchange combina-  
tions are differentiated by the random number generator  
5    2204, it is substantially impossible to decode the true  
data from a bit train output.

Fig. 28 is a circuit diagram showing 9 still  
another embodiment of the security circuit suitable for  
duplication prevention used with a digital signal  
10    selling system according to the present invention. In  
this embodiment, as in the embodiment shown in Fig. 26,  
the bit-rearranging circuit 2801 is used for address  
input. Fig. 29, on the other hand, is a specific  
circuit diagram showing an embodiment of the bit-  
15    rearranging circuit 2801 similar to the one shown in  
Fig. 27 used with the security circuit. The concept of  
this embodiment is identical to that of the embodiments  
shown in Figs. 26 and 27 except that the data and  
address have different bit lengths.

20    Fig. 30 is a block diagram showing an embodi-  
ment of a digital audio signal processor for realizing  
fast and slow playback with high sound quality.

According to the digital signal selling system  
mentioned above, fast playback is considered effective  
25    for listening to such information as news and various  
market situations in short time. In the case where the  
player user is an aged person or the like, on the other  
hand, it is considered effective to add the slow play-

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1 back function in view of the fact that it takes some  
time before the language is understood.

In an analog-type recording system such as the  
conventional cassette tape recorder, the tape speed may  
5 be changed to assure slow or fast playback by changing  
the playback time as compared with the recording time.  
When the tape speed is changed this way, however, the  
pitch (frequency) is also undesirably changed, resulting  
in the loss of fidelity to the original sound, thereby  
10 making it very hard to listen to.

On the other hand, the playback speed may be  
changed without changing the pitch by the use of the  
signal processing technique using a digital signal  
processor or the like. In such a system, however, the  
15 configuration is complicated with an increased power  
consumption, with the result that it cannot be mounted  
on the portable player and at the same time the cost is  
very high. Further, such a system is effective only for  
voice and the reproduction of a music program is  
20 difficult.

According to the present embodiment, the voice  
interval contained in the audio information is utilized  
in such a manner that the voice interval is shortened or  
substantially deleted for fast playback and enlarged or  
25 extended for slow playback. By employing this system, a  
high sound quality is maintained since the pitch of the  
original sound remains unchanged in both fast and slow  
playbacks. In addition, this configuration, as des-

1 cribed later, is realizable with a comparatively simple  
combination of logic circuits without using any expen-  
sive, complicated devices like the digital signal  
processor, thus making possible a system low in price  
5 and small in size.

The embodiment of Fig. 30 concerns a case in  
which the system is mounted on the player 101 of the  
digital signal selling system.

The digital audio signal read from the memory  
10 circuit 701 is inputted to a digital-to-analog converter  
707 on the one hand and to a voice interval detector  
3002 on the other hand. The voice interval detector  
3002 may be made up of a circuit similar to the one used  
in the quantizing noise neglecter 1500 in the embodiment  
15 of Fig. 15. In the case where the quantizing noise  
remover 1500 is also incorporated, the voice interval  
detector 3002 may be shared therewith in operation. The  
output signal of the voice interval detector 3002 is  
inputted to a fast/slow playback circuit 3003. The fast  
20 or slow playback is designated for the fast/slow  
playback circuit 3003 under the control signals of modes  
1 and 2. This fast/slow playback circuit 3003 controls  
the operation of the address counter 703 for forming a  
read address signal of the memory circuit 701 in  
25 response to a mode signal. When the fast playback is  
designated by mode 1, for example, the clock frequency  
is increased beyond normal level to increase the speed  
of reading the memory circuit 701 during a voice

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1 interval which may be detected, thus substantially  
shortening the voice interval to achieve fast playback.

Assume that the slow playback is designated by  
mode 2. When a voice interval is detected, the clock  
5 frequency is decreased below normal level or suspended  
for a predetermined length of time thereby to enlarge or  
extend the read time for the memory circuit 701 during  
the voice interval, thus achieving the slow playback.  
The output signal of the address counter 703 is inputted  
10 to the memory circuit 701 through the multiplexer 702.  
When a digital signal is written into the memory circuit  
701, the multiplexer 702 causes an external address  
signal to be inputted to the memory circuit 701, while  
when a digital signal stored in the memory circuit is  
15 read, i.e., at the time of playback of the digital  
signal, the address signal generated by the address  
counter 703 is inputted to the memory circuit 701.

Fig. 31 is a block diagram showing a specific  
embodiment of the fast playback circuit.

20 According to this embodiment, the output  
signal of the voice interval detector 3002 is supplied  
through an inverter 3102 to an AND gate 3103. This AND  
gate 3103 is for inputting the digital signal from the  
memory circuit 701 to a digital-to-analog converter 707,  
25 and is configured the same way as the quantizing noise  
remover 1500. Specifically, this embodiment is intended  
to achieve the fast playback while at the same time

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1 eliminating the quantizing noises during the same  
interval.

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The output signal of the voice interval  
detector 3002 is inputted to the control terminal S of  
5 the multiplexer 3101. The mutiplexer 3101 is adapted to  
input two clock pulses CK1 and CK2 selectively to the  
address counter 703 in accordance with the output signal  
of the voice interval detector 300 inputted to the  
control terminal S. The clock pulse CK1, for example,  
10 is one corresponding normally to playback, and is  
adapted to have a frequency corresponding to the  
sampling rate of the digital signal. The clock pulse  
CK2, by contrast, is used for fast playback and has a  
frequency about ten times higher than the clock pulse  
15 CK1.

As long as the fast playback is designated,  
upon judgement of a voice interval by the voice interval  
detector 3002, the output signal is raised to high level  
(logic "1"). In response to this, the output signal of  
20 the inverter 3103 is reduced to low level (logic "0"),  
and the AND gate 3103 is closed. In the case of a  
digital signal of 2' complement binary code as mentioned  
above, therefore, the digital signal inputted to the  
digital-to-analog converter 707 during a voice interval  
25 is forcibly made to correspond to the "0" level. Also,  
with the rise of the output signal of the voice interval  
detector 3002 to high level, the multiplexer 3101 inputs  
the clock CK2 instead of the clock CK1 to the address

1 counter 703. As a result, the address counter 703  
updates the address at the rate ten times higher than in  
normal playback operation. The voice interval is thus  
shortened to about one tenth, thus assuring fast  
5 playback equivalently.

An experiment conducted by the inventor shows  
that the voice interval accounts for a comparatively  
long time or 30% to 50% of every type of conversation or  
lecture as well as the news program in which a text is  
10 read. By eliminating this voice interval virtually, the  
playback time can be shortened to about  $2/3$  to  $1/2$ .

At the end of a voice interval, the normal  
playback is immediately restored, and therefore the  
sound quality remains the same as the original sound,  
15 thereby making it very easy to listen to. In the case  
where the fast playback is to be stopped in the circuit  
according to the present embodiment, the only thing  
required is to input the output signal of the voice  
interval detector 3002 to the control terminal S of the  
20 multiplexer 3101 through the AND gate and the like newly  
added. When no fast playback is desired, on the other  
hand, the input to the AND gate is reduced to "0".  
Then, the control terminal S of the multiplexer 3101 is  
always kept at low level, so that the clock CK1 is  
25 inputted to the address counter 703 even during a voice  
interval and a voice interval level is outputted for a  
time length corresponding to the voice interval. In the  
process, the AND gate 3103 functions as a quantizing

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1 noise remover to prevent a quantizing noise from being  
generated during the particular period.

Fig. 32 is a block diagram showing a specific embodiment of the slow playback circuit.

5           This embodiment is intended to generate a voice interval enlarged in proportion to the true voice interval for slow playback. The output signal of the voice interval detector 3002 described above is supplied to the set input S of a flip-flop 3201 on the one hand, 10 and to one of the inputs of the AND gate 3210 on the other hand. The other input terminal of the AND gate 3210 is supplied with a clock pulse CK3 for measuring the voice interval. The output signal of the AND gate 3210 is inputted to a voice interval counter 3202.

15 During the period when the presence of a voice interval is judged by the voice interval detector 3002, the voice interval counter 3202 counts the clock pulses CK3 thereby to conduct a counting operation corresponding to the particular voice interval. The counter 3205 counts 20 the clock pulses CK3 supplied thereto through the AND gate 3211. The voice interval counter 3202 is for holding information as well as for measuring the time of the voice interval. The counter 3205 for counting the same clock pulses CK3 as this voice interval information 25 performs the operation of reproducing the particular voice interval. Specifically, the outputs of the voice interval counter 3202 and the counter 3205 are inputted



The N counter 3204 is for designating the voice interval at N times as longer, and though not specifically limited, has an N value variable. The N counter 3204 is of programmable type, and when the count Q comes to coincide with N, outputs a coincidence signal Q (= N) and resets the flip-flop 3201. This N counter 3204 may also be realized by using a down counter.

The output signal Q of the flip-flop 3201 is  
15 inverted by the inverter 3209 and is used as a control  
signal for the AND gate 3208 having the function of  
neglecting quantizing noises. The output signal Q is  
also used for controlling the AND gate 3211 for  
supplying the clock pulse CK3 to the counter 3205 and  
20 the AND gate 3206 through the inverter 3207 at the same  
time. This AND gate 3206 functions as a gate for  
supplying the clock pulse CK1 selectively to the address  
counter 703.

The circuit operation of this embodiment will  
25 be described. Upon detection of a voice interval at the  
voice interval detector 3002, the AND gate 3210 opens to  
supply the clock pulse CK3 to the voice interval counter  
3202. As a result, the voice interval counter 3202

1 counts the clock pulses CK3 as long as a voice interval  
is judged by the voice interval detector 3002. When the  
voice interval detector 3002 judges that an audio  
digital signal has been inputted, the flip-flop 3201 is  
5 set in synchronism with the change of the detection  
signal from high to low level, so that the output signal  
Q becomes high in level, and a digital signal associated  
with the voice internal level is supplied to the  
digital-to-analog converter 707 in place of the digital  
10 signal from the memory circuit 701.

In accordance with the change of the output  
signal Q of the flip-flop 3201 to logic "1", the output  
signal of the inverter 3207 becomes logic "0", thereby  
closing the AND gate 3206. As a consequence, the  
15 address counter 703 is not supplied with any clock pulse  
CK1, and therefore is left to hold the previous address.  
In other words, the reading operation of the memory  
circuit 701 is stopped.

With the change of the output signal Q of the  
20 flip-flop 3201 to logic "1", the AND gate 3211 opens,  
and the counter 3205 starts to count the clock pulses  
CK3. When the count becomes equal to that of the voice  
interval counter 3202, the comparator 3203 outputs a  
coincidence signal  $A = B$ , thereby energizing the N  
25 counter 3204 while at the same time resetting the  
counter 3205. When the N counter counts the value N as  
a result of repeating these processes of operation, the  
flip-flop 3201 is reset. Specifically, when the voice

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1 interval measured by the voice interval counter 3202  
increases N times as large, the flip-flop 3201 is reset.  
With the resetting of the flip-flop 3201, the AND gate  
3206 opens again, and inputs the clock pulse CK1 to the  
5 address counter 703. As a result, the reading of the  
digital signal from the memory circuit 701 is sub-  
stantially restarted. At the same time, the AND gate  
3208 is opened, and the digital signal thus read is  
supplied to the digital-to-analog converter 707. Thus  
10 the audio signal is outputted again. In this configura-  
tion, the extension of the voice interval is propor-  
tional to the voice interval of the original sound.  
Therefore, a conversation or lecture is accordingly  
increased in the length of interval and is made less  
15 offensive to the ear.

When a voice interval is counted, the  
quantizing noise is outputted as described above. For  
removing this quantizing noise generated during the  
counting of a voice interval, a method is by inverting  
20 the output signal of the voice interval detector 3002  
through an inverter to control the AND gate 3208. In  
such a case, a three-input AND gate is used as the AND  
gate 3208. When a voice interval is counted, the  
quantizing noise is eliminated by the output signal of  
25 the voice interval detector 3002 added as above, and by  
the output signal Q of the flip-flop 3201 while the  
voice interval is enlarged subsequently, as described  
above.

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1           Fig. 33 shows waveforms of operation  
associated with the fast playback circuit of Fig. 31.  
The voice intervals 3303 (Tm1) and 3304 (Tm2) of the  
original signal 3301 can be removed substantially by  
5 switching the clock pulses supplied to the address  
counter 703 during such intervals, and therefore the  
fast playback is made possible without changing the  
pitch (frequency) of the audio signal, i.e., without  
deteriorating the sound quality of the audio signal.

10           Fig. 34 shows waveforms of operation  
associated with the slow playback circuit of Fig. 32.  
Since the voice intervals 3303 (Tm1) and 3304 (Tm2) of  
the original signal are enlarged to n times as large by  
suspending the operation of the address counter 703  
15 during the same intervals, the slow playback is realized  
without changing the pitch (frequency) of the audio  
signal, i.e., without deteriorating the sound quality of  
the audio signal.

Fig. 35 is a block diagram showing another  
20 embodiment of the fast playback circuit according to the  
present invention.

In this embodiment, the address-generating  
operation is directly switched by using an adder 3501  
with the address counter 3503 in order to achieve fast  
25 playback. Specifically, the address counter 3503  
includes the adder 3501 and a register 3503 for  
receiving a sum output A+B thereof. The output signal Q  
of the register 3503 is fed back to the sum input A on

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1 the one hand, and is inputted to multiplexer 702 as a  
read address of the memory circuit 701 on the other  
hand.

The other input B of the adder 3501 is  
5 supplied selectively with 1 and a positive integer M  
through the multiplexer 3504. The control terminal S of  
the multiplexer 3504 is supplied with an output signal  
of the voice interval detector 3002. The output signal  
of the voice interval detector 3002 is supplied also to  
10 the AND gate 3505 for eliminating the quantizing noise  
through the inverter 3209 as in the aforementioned  
embodiment.

When a voice interval is detected by the voice  
interval detector 3002, the multiplexer 3504 selects M  
15 in place of 1, and transmits it to the adder 3501. As a  
result, before entering a voice interval, the adder 3501  
performs the counting operation by adding +1 to the  
address signal formed by the register 3502 and gener-  
ating the next address signal. When a voice interval is  
20 entered as mentioned above, the multiplexer 3504 inputs  
M to the adder 3501. As a result, the adder 3501 adds  
+M to the address signal formed by the register 3502 to  
generate an address signal skipped by M addresses. Thus  
the address-updating operation during a voice interval  
25 is equivalently increased in speed, thereby sub-  
stantially eliminating the voice interval as in the  
aforementioned embodiments.

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1           Fig. 36 is a block diagram showing another  
specific embodiment of the slow playback circuit  
according to the present invention.

          In this embodiment, a clock pulse CK4 is  
5 prepared for slow playback. Specifically, in contrast  
to the fast playback circuit shown in Fig. 31, a slow  
clock pulse CK4 is prepared for slow playback, so that  
when a voice interval is started, the multiplexer 3601  
is switched to select the slow playback clock pulse CK4  
10 in place of normal clock pulse CK1. When the frequency  
of the clock pulse CK4 is reduced to  $1/N$  in comparison  
with that of the clock pulse CK1, the operation of the  
address counter 703 is decreased by a factor of  $N$ ,  
thereby enlarging the voice interval equivalently by a  
15 factor of  $N$ .

          In this embodiment, which can be configured  
with a circuit similar to Fig. 31, the input B of a  
multiplexer 3601 may be selectively supplied with the  
clock pulse CK2 in fast playback mode and the clock  
20 pulse CK4 in slow playback mode respectively through a  
similar multiplexer or an appropriate switching circuit.  
In this way, both the fast and slow playback are made  
possible.

          Fig. 37 is a block diagram showing another  
25 specific embodiment of a slow playback circuit according  
to the present invention.

          In slow playback mode, the user like an aged  
person feels more convenient to hear as described above.

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Fig. 38 is a schematic diagram for explaining an example of operation of the circuit shown in Fig. 37.

20 The original data 3801 has a maximum extension time  $T_{max}$  corresponding to K. Assume that the voice interval  $T_d$  of the original data 3801 is larger than the maximum extension time K. When the output signal Q of the voice interval counter 3202 supplied to the input A of the

25 comparator 3707 increases beyond the maximum extension time K supplied to the input B of the comparator 3707, the comparator output  $A \geq B$  of the comparator 3701 becomes logic "1". As a result, the flip-flop 3714, the



voice interval counter 3202 and the extension counter 3702 are reset through the OR gate 3701, thereby nullifying the slow playback mode equivalently. The state after the slow playback operation thus remains the same as that before the slow playback operation. In this way, in the case where the voice interval of the original signal 3801 is so long as to fail the object of slow playback as mentioned above, the operation of extending the voice interval is substantially nullified.

Fig. 39 is a schematic diagram for explaining another example of operation of the circuit shown in Fig. 37. In Fig. 39, as in the previous case, the original data 3901 has a maximum extension time  $T_{max}$  corresponding to  $K$ . In the case where the voice interval  $T_d$  of the original data which is shorter than the maximum extension time  $K$  becomes longer than the maximum extension time  $K$  as a result of being increased  $N$  times as long, the comparator 3706 detects the fact that the voice interval  $T_d \times N$  determined by the multiplier 3703 increases beyond the maximum extension time  $K$  and sets the comparator output  $A \geq B$  to logic "1". In response to the logic "1" state of the comparator output signal, the multiplexer 3705 transmits the maximum extension time  $K$  of the input  $B$  in place of the multiplier output  $T_d \times N$  of the input  $A$  to the comparator 3704. As a result, when the output signal  $Q$  of the extension counter 3702 exceeds the maximum extension time mentioned above, the output  $A \geq B$  of the

1 comparator 3704 becomes logic "1", so that the flip-flop  
3714, the voice interval counter 3202 and the extension  
counter 3702 are reset through the AND gate 3701. In  
this way, the processed data 3902 is used to limit the  
5 extension time of a given voice interval to less than  
the maximum extension time.

Fig. 40 is a schematic diagram for explaining  
still another example of operation of the circuit shown  
in Fig. 37. In Fig. 40, as in the previous cases, the  
10 original data 4001 has a maximum extension time  $T_{max}$   
corresponding to  $K$ . In the case where the voice  
interval  $T_d$  of the original data 4001 is shorter than  
the maximum extension time  $K$  and the time length  $N$  times  
the voice interval  $T_d$  is still shorter than the maximum  
15 extension time  $K$  in this way, the comparator 3706  
detects the fact that the voice interval  $T_d \times N$   
determined by the multiplier 3703 is shorter than the  
maximum extension time  $K$ , and sets the comparator output  
 $A \geq B$  to logic "0". In response to this logic "0" of  
20 the comparator output, the multiplexer 3705 transmits  
the multiplier output  $T_d \times N$  of the input  $A$  to the  
comparator 3705. As a result, when the output signal  $Q$   
of the extension counter 3702 exceeds the enlarged voice  
interval  $T_d \times N$ , the comparator output  $A \geq B$  of the  
25 comparator 3704 becomes logic "1", so that the flip-flop  
3714, the voice interval counter 3202 and the extension  
counter 3702 are reset by way of the AND gate 3701. In

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1 this way, the voice interval is enlarged N times as long  
in the processed data 4002.

Fig. 41 shows waveforms for explaining another  
embodiment of the fast and slow playback operations.

5 According to the present embodiment, the data  
compression function is included in addition to the fast  
and slow playback. In other words, the voice intervals  
3303, 3304 of the original data 3301 are replaced by the  
voice interval data 4102 (MK) as shown in the processed  
10 signal 4101. In Fig. 41, the voice interval data 4102  
(MK) represents a point of insertion thereof, and at the  
time of actual analog conversion, the part where the  
voice interval data 4102 (MK) is inserted is rendered  
voiceless. By inserting this voice interval data 4102  
15 (MK), the voice intervals 3303, 3304 are replaced by  
information of several bytes, and therefore the voice  
intervals 3303, 3304 contained in the digital signal  
before analog conversion are substantially removed. As  
a consequence, the memory capacity required for storing  
20 digital signals can be reduced to about 1/2 to 2/3 or by  
the proportion which the voice interval represents of  
the whole time length. In the case where a data is com-  
pressed in this way, utilization of the voice interval  
data 4102 (MK) makes slow or fast playback possible by  
25 enlarging or compressing the same signal selectively.  
This data compression may basically use a fast playback  
controller as described above. Although the fast  
playback controller outputs a "0" level signal in order

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1 to remove the quantizing noise during a voice interval,  
the voice interval data 4102 (MK) may alternatively be  
inserted with equal effect.

Fig. 42 is a pattern diagram showing an  
5 embodiment of the voice interval data 4102 (MK).

The voice interval data 4102 (MK) includes a  
voice interval mark 4203 and a voice interval time data  
4204. A combination of bit patterns unavailable for a  
normal digital signal is selected as the voice interval  
10 mark 4203. According to this embodiment, when the  
digital signal is a 2' complement binary code, a  
combination of a positive maximum value 4201 (01111111)  
and a negative maximum value 4202 (1000000) is used. A  
normal audio signal does not change from a positive to a  
15 negative maximum value, and therefore this combination  
is used as a voice interval mark. The voice interval  
mark 4203 may alternatively be a combination of two,  
three or four bytes, unlike in the above-mentioned  
combination.

20 The voice interval time data 4204, though not  
specifically limited, may have two bytes. In order to  
meet the requirement of a longer voice interval,  
however, three or four bytes may be used for the voice  
interval time data 4204.

25 Fig. 43 is a block diagram showing an  
embodiment of a digital signal playback controller  
including the function of fast and slow playback modes

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1 against the digital signal compressed in the manner  
described above.

The address counter 703 is supplied with an  
address counter clock ADCK through an AND gate 4311.

5 When the voice interval data 4102 (MK) includes a two-  
byte voice interval mark 4203 and a two-byte voice  
interval time data as mentioned above, the read signal  
for the memory circuit 701 is outputted through four-  
stage shift registers 4301a to 4301d correspondingly  
10 thereto. These shift registers 4301a to 4301d are  
supplied with a data shift clock DSCK through an AND  
gate 4312.

The outputs A and B of the shift registers  
4301d, 4301c are inputted to a voice interval mark  
15 detector 4303. The mark detector 4303 compares the bit  
patterns of the signals A and B to determine whether  
they coincide with the positive maximum value 4201  
(01111111) and the negative maximum value 4202  
(10000000) respectively. The detection signal from the  
20 voice interval mark detector 4303 is used for setting  
the flip-flops 4308 and 4309.

The outputs C and D of the shift registers  
4301b and 4301a are supplied to an input A of the  
comparator 4304. The other input B of the comparator  
25 4304 is supplied with the output signal of the voice  
interval counter 4305. The output signal of the  
comparator 4304 is supplied through the AND gate 4315 to  
the reset terminal R of the voice interval counter 4305

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1 and the input CK of the repeat counter 4306 used for  
extending a voice interval. The output Q of the repeat  
counter 4306 is compared with an extension factor N at  
the comparator 4307.

5               The output Q of the flip-flop 4309 is supplied  
through the inverter 4314 to the OR gate 4315 and the  
AND gates 4311, 4312. Upon detection of the voice  
interval mark 4203, therefore, the operation of the  
address counter 703 and the shifting operation of the  
10 shift register 4301a to 4302d are stopped, thereby  
holding the voice interval data 4102 (MK) in the shift  
registers 4301a to 4301d. With the stoppage of  
operation of the address counter 703, the memory circuit  
701 has the reading operation thereof suspended. The  
15 output signal of the comparator 4307 is supplied to the  
reset terminal R of the flip-flop 4309 and the repeat  
counter 4306.

              The output Q of the flip-flop 4308 is set as a  
voice interval flag FLG and makes up a control signal  
20 for the AND gate 4310 through the inverter 4313. Upon  
detection of a voice interval mark this way, the AND  
gate 4310 is immediately closed, thereby preventing the  
positive maximum value 4201, the negative maximum value  
4202 and the following time data 4204 from being  
25 outputted erroneously as an audio signal. Especially  
when the positive and negative maximum values are used  
as a voice interval mark 4203, a large pulse-like noise

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1 would be caused if such values are outputted directly in  
their own forms.

The voice interval flag of the flip-flop 4308  
is fed back through four-stage D-type flip-flops 4302a  
5 to 4302d as a reset signal for the flip-flop 4308.  
These flip-flops 4302a to 4302d, as explained below, are  
used to transmit the voice interval by the same data  
shift clock as the shift registers 4301a to 4301d,  
thereby detecting a time period, at the end of the voice  
10 interval, in which the voice interval data 4102 (MK)  
including the voice interval mark 4203 and the time data  
4204 thus far held in the shift-registers 4301a to 4301d  
is swept out. When it is judged by the flip-flops 4302a  
to 4302d that the voice interval has been ended, the  
15 flip-flop 4308 is reset.

After the flip-flop 4309 is set upon detection  
of the voice interval mark 4203, the reset state of the  
voice counter 4305 is cancelled through the inverter  
4314. The voice interval counter 4305 starts the  
20 counting operation of the voice interval clock SCLK in  
response to the cancellation of the reset state.

In normal playback mode, the N value supplied  
to the comparator 4307 is set to 1. As a result, when  
the count of the voice interval counter 4305 coincides  
25 with the voice interval time 4204 contained in the voice  
interval data 4102 (MK), the coincidence signal out-  
putted from the comparator 4304 is incremented by +1 by  
the repeat counter 4306, thereby rendering the count as

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1 1. Since the comparator 4307 forms a coincidence output  
signal at the same time, the repeat counter 4306 and the  
flip-flop 4309 are reset. With the resetting of the  
flip-flop 4309, the AND gates 4311, 4312 are opened, and  
5 the memory circuit 701 is read through the address  
counter 703 while at the same time restarting the  
shifting operation on the shift registers 4301a to  
4301d. In synchronism with the shifting operation of  
the shift registers 4301a to 4301d, the voice interval  
10 flag FLG is sequentially transmitted by the flip-flops  
4302a to 4302d. Specifically, until the voice interval  
data 4102 (MK) thus far held in the shift registers  
4301a to 4301d is swept out, the flip-flop 4308 is kept  
in set state, and the resulting signal is prohibited  
15 from being outputted as an audio noise by being  
transmitted from the digital-to-analog converter 707.  
In synchronism with the voice interval data 4102 (MK)  
being swept out, the flip-flop 4308 is reset. As a  
result, a substantial voice interval is ended, and the  
20 digital audio signal outputted from the final-stage  
shift register 4301d is inputted to the digital-to-  
analog converter 707 through the AND gate 4310, thereby  
assuring playback of an audio signal.

In slow playback mode, the N value supplied to  
25 the comparator 4307 is set to an appropriate integer of  
1 or more. Assume that the N value is set to 2, for  
instance. When the count of the voice interval counter  
4305 and the voice interval contained in the voice



1 interval data 4102 (MK) make two rounds, the comparator  
4307 forms a coincidence signal, thereby ending a voice  
interval of double length. If N is set to 3, on the  
other hand, the voice interval can be extended by a  
5 factor of three.

In fast playback mode, the operation of the  
flip-flop 4309 is nullified. Specifically, the output  
signal of the voice interval mark detector 4303 is  
prohibited from being supplied through an AND gate or  
10 the like to the set input S of the flip-flop 4309. In  
such a case, the address counter 703 and the registers  
4301a to 4301d continue to be supplied with a clock, and  
therefore the reading operation of the memory circuit  
701 is continued. Since the flip-flop 4308 is set by  
15 the detection output of the voice interval mark detector  
4303, however, the inverter 4313 and the AND gate 4310  
prohibit the voice interval data 4102 (MK) from being  
inputted to the digital-to-analog converter 707 as an  
audio signal. Specifically, the voice interval makes up  
20 only a very short period of time during which the audio  
data is outputted, thereby substantially eliminating the  
voice interval, with the result that the fast playback  
is made possible as in the embodiments described above.

A digital signal processor for realizing the  
25 fast and/or slow playback mode mentioned above is not  
only used with a player of a digital information system  
mentioned above but also is applicable to various  
reproduction systems including a digital signal

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1 processor for reproducing a digital audio signal as an  
analog audio signal such as the digital audio tape  
(DAT).

In a digital audio system or the like, the  
5 code is compressed in order to lengthen the recording  
time. A well-known compression system employable in the  
digital signal receiving/deliver system proposed by this  
invention includes an adaptive PCM, an adaptive  
differential PCM and an adaptive  $\Delta M$ . Among these  
10 systems, the adaptive differential PCM is standardized  
and employed as an audio compression system such as CD-1  
and CD-ROM. For the purpose of data compression, a  
method may be used which meets the object and  
configuration requirements of various compression  
15 systems including the above-mentioned three systems and  
the data compression or expansion system according to  
the present invention.

The amplitude and the frequency distribution  
of an acoustic signal are subjected to a comparatively  
20 gentle but great change with the lapse of time. A  
method of coding with the quantizing step width changed  
in accordance with the characteristics of the neighbor-  
ing signals is an adaptive PCM (APCM). This adaptive  
PCM is for changing the quantizing step width in accord-  
25 ance with the amplitude of an immediately preceding  
sample quantization value. The adaptive differential  
PCM, on the other hand, is for introducing the adaptive  
step width into the difference PCM not to quantize the

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1 signal directly but to quantize it indirectly from the  
differential with a prediction value. And  $\Delta M$  is a  
coding method for quantizing a signal by one bit. This  
method is accompanied by a large strain under an abrupt  
5 signal change. The adaptive  $\Delta M$ , in contrast, is such  
that the quantizing step width is increased when the  
same code is continued, and reduced when a code is  
inverted.

The adaptive PCM, the adaptive differential  
10 PCM and the adaptive  $\Delta M$  require a multiplier circuit for  
changing the step width, and a complicated circuit  
becomes necessary such as a microcomputer or a digital  
signal processor, thus leading to the disadvantage of a  
large circuit scale. On the other hand,  $\Delta M$ , which has a  
15 large quantization strain, lacks the fidelity.

Figs. 44, 45 and 46 are block diagrams showing  
an embodiment relating to a data compression and expan-  
sion system advantageous in terms of power consumption  
and suited for reducing the size with a simple  
20 configuration.

The object of this embodiment is to provide a  
data conversion system and a data converter circuit high  
in fidelity by a simple configuration in relation to the  
data compression and expansion.

25 Fig. 44 is a block diagram showing an embodi-  
ment of a data converter configured by a data conversion  
system according to the present invention.

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1           The data converter according to this embodi-  
ment, though not specifically limited, is for converting  
an analog signal into a 16-bit digital signal and is  
intended for a circuit for compressing and outputting  
5 the digital data as an 8-bit digital data.

          The analog signal Vin is inputted to the  
analog-to-digital converter 4401 and is converted into a  
digital data of n bits (16 bits, for example, as  
mentioned above). This embodiment uses a circuit  
10 described below for compressing the digitally-converted  
16-bit data into a data of m bits (8 bits, for example).

          One of the inputs of the subtractor 4402 is  
supplied with the 16-bit data D1 digitally converted as  
above. The other input of the subtractor 4402 is  
15 supplied with a 16-bit data D2 stored in the register  
4406. The 16-bit data D2 stored in the register 4406 is  
assumed to be an immediately preceding sampling data as  
described later. The subtractor 4402 subtracts the  
immediately preceding sampling data D2 stored in the  
20 register 4406 from the input data D1 digitally  
converted, and outputs the difference (D1 -D2)  
therebetween. The difference data D3 is supplied to an  
input B of the comparator 4403. The other input A of  
the comparator 4403 is supplied with a data D4 corre-  
25 sponding to the maximum value of an 8-bit data to be  
compressed. This data D4 is comprised of 16 bits of  
0000000011111111 (255 in decimal notation) as shown with  
all the least significant eight bits (m) as 1.

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1           The comparator 4403 compares the data D3 and  
D4 supplied to the input terminals A and B, and when B  
is larger than A ( $D3 > D4$ ), forms a high-level output  
signal, while when A is larger than B generates a low-  
5 level output signal. The output signal of the com-  
parator 4403 is used as a selection signal.

          An input A of the selector 4404 is supplied  
with an 8-bit maximum value data d4 to be compressed  
(11111111), and the input B with a data d3 representing  
10 the least significant eight bits of the difference data  
D3. The selector 4404 selects and outputs the maximum  
value data d4 of the input A when the output signal of  
the comparator 4403 is at high level, i.e., when the  
subtraction data D3 is larger than D4, and the data d3  
15 of the least significant eight bits of the subtraction  
output supplied to the input B when the output signal of  
the comparator 4403 is at low level, i.e., when the  
subtraction data D3 is smaller than D4.

          The output signal d5 of the selector 4404,  
20 though not specifically limited, is stored in the memory  
4408, and read and outputted as a compressed 8-bit  
digital data Dout. The output signal d5 of the selector  
4404 is supplied to one of the inputs of the adder 4405.  
The other input of the adder 4405 is supplied with the  
25 output data D2 of the register 4406. As a result, the  
adder 4405 adds the compressed data d5 outputted from  
the selector to the immediately preceding sampling data  
D2 stored in the register 4406, so that the sampling

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1 data D2' updated and assumed to be immediately preceding  
to the next input data D1 is formed and stored in the  
register 4406. In this way, the accumulation error is  
prevented by generating the next sampling data by the  
5 register 4406 and the adder 4405.

Subsequently, the 16-bit (n-bit) input data D1  
is converted into an 8-bit (m-bit) compressed data d5 by  
repeating similar processes.

Fig. 45 shows waveforms for explaining the  
10 operation of analog-to-digital conversion accompanied by  
the data compression described above.

At the time of data compression, the register  
4406 is cleared of data (0000000000000000). As a  
result, when an analog signal rises sharply as shown,  
15 the progressive adding operation of the least  
significant 8-bit maximum value would fail to follow an  
input digital signal. Once the difference between the  
input digital signal and the immediately preceding  
sampling data is reduced below the maximum value of the  
20 compressed data, however, it is possible to obtain a  
compressed data faithfully corresponding to the input  
signal change. As for an acoustic signal which has an  
amplitude and a frequency distribution changing  
comparatively gently with time, data compression is  
25 possible with a fidelity posing no practical problem.

Fig. 46 is a block diagram showing another  
embodiment of a data converter in a data conversion  
system according to the present invention. This

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1 embodiment is intended for a circuit in which a data  
compressed into m bits (eight bits, for example) as in  
the aforementioned embodiment is extended into an n-bit  
(16-bit) data and at the same time is outputted by being  
5 converted into an analog signal.

The data Din compressed by a data compressor  
as shown in Fig. 44, though not specifically limited, in  
transferred and stored in a memory 4601 of Fig. 46 from  
the memory 4408 in Fig. 44. In some cases, the memory  
10 4408 in Fig. 44 and the memory 4601 in Fig. 46 are used  
in common with each other. The data d5 read out of the  
memory 4601 is supplied to an input of the adder 4602.  
The other input of the adder 4602 is supplied with an n-  
bit data D6 stored in the register 4603. The adder 4602  
15 forms a data D7 by adding the data d5 to D6. This data  
D7, though not specifically limited, is inputted to the  
register 4603. The data D6 outputted from the register  
4603 and extended is inputted to the digital-to-analog  
converter 4604 to form a demodulated analog signal Vout.

20 The operation of the data extender will be  
explained. At the time of starting the data extending  
operation, the register 4603 is cleared as in the  
aforementioned case. The compressed data d5 read out of  
the memory 4601 is added to an immediately preceding n-  
25 bit data D6 of the register 4603 each time of reading,  
and is stored in the register 4603 as expanded data. As  
a result, the expanded data is restored which changes in

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1 steps in accordance with the change components due to  
the compressed data d5 as shown in Fig. 45.

The effects obtained from the above-mentioned  
embodiment are as follows:

5 (1) The difference between the immediately  
preceding sampling data and an input data is determined,  
and when the difference is larger than the maximum value  
of a compressed code, the particular maximum value is  
outputted, while when the difference is smaller than the  
10 same maximum value, the result of subtraction is  
outputted to output compressed data, thus compressing  
data. In this method, the data such as an acoustic  
signal having an amplitude or a frequency distribution  
changing comparatively gently with time can be com-  
15 pressed with high fidelity with a simple configuration  
of subtraction and addition.

(2) According to the effect (1) above, a data  
compressor or expander can be realized with a simple  
circuit including a subtractor, an adder, a register and  
20 a comparator. Also, the power consumption is minimized.

(3) By using a data converter system and circuit  
mentioned above, the player for reproducing an acoustic  
signal stored in a memory can be reduced in size and  
weight.

25 Although the present invention has been  
described specifically above with reference to  
embodiments, the invention is not limited to these  
embodiments but various modifications thereof are of

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1 course possible without departing from the spirit of the  
invention. In Fig 44, for instance, in place of the  
configuration for comparing the subtractor output data  
D3 with the maximum value D4 of a compressed data by a  
5 comparator, an OR gate or the like may be used to form a  
comparator output larger or smaller than the maximum  
value equivalently on the basis of the fact that at  
least any one of the most significant bits of the  
subtractor output data D3 is "1". Also, the data D2 of  
10 the register less the input data D1 may be used as the  
difference data.

The input data compressed, instead of the  
output signal of the analog-to-digital converter as  
shown in the embodiment of Fig. 44, may be such as a  
15 digitally-converted data stored in a memory, a magnetic  
tape or a compact disk with equal effect. The com-  
pressed data may be converted into a serial data and  
outputted through a communication channel or the like.

The data converter system and the analog-to-  
20 digital converter according to the present invention are  
widely applicable with circuits and systems handling a  
digital data changing with time.

Fig. 47 is a block diagram showing an  
embodiment of a digital-to-analog converter according to  
25 the present invention. This digital-to-analog  
converter, though not specifically limited, is mounted  
on the player 101 used with the digital information  
system described above.

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This digital-to-analog converter, which forms an output signal converted into one pulse width from an input digital signal, poses the problem that as a result of smoothing the input digital signal through a filter, a ripple component is generated making it impossible to produce an analog signal of high sound quality. Specifically, if the responsiveness (high-frequency characteristics) of an analog signal is to be improved, it is necessary to reduce the time constant of the low-pass filter. If the time constant of the low-pass filter is thus reduced, however, the ripple component is undesirably increased. If the time constant of the filter is increased to reduce the ripple component, on the other hand, the response characteristic against the input signal change is deteriorated, thereby deteriorating the high-frequency characteristics. Also, the

1 necessity of both a counter and a comparator complicates  
the circuit configuration.

The digital-to-analog converter shown in Fig. 47 is aimed at improving such output characteristics.

5           The digital-to-analog converter according to  
the present embodiment includes circuits described below  
in order to remove the ripple component contained in the  
output signal. The input digital signal Din is supplied  
to the register 4701. The input digital signal thus  
10 supplied to the register 4701 is supplied to an input A  
of the comparator 4702. The counter 4703 is for count-  
ing pulses as a reference time signal repeatedly. The  
carry output signal CAR of this counter 4703 is supplied  
to the repeat counter 4704. The repeat counter 4704  
15 outputs the carry output CAR upon counting a designated  
repeat count J. This carry output CAR is inputted to  
the controller 4705 for outputting a conversion-over  
signal EOC.

The controller 4705, upon receiving a strobe  
20 synchronous with the input digital signal Din, supplies  
a set signal S to the register 4701 thus giving an  
instruction on retrieval of the digital signal Din.  
Though not specifically limited, the controller 4705,  
upon retrieval of the input signal Din by the register  
25 4701 in response to the reference time pulse CK of 10  
MHz, supplies the same signal to the counter 4703 to  
start the counting operation.

1           The comparator 4702 forms a high-level output  
signal when the input digital signal Din supplied to the  
register 4701 is larger than the count Q of the counter  
4703 ( $A > B$ ). This comparator 4702 forms a low-level  
5 signal when the count output Q of the counter 4703  
increases beyond the data line input digital signal Din  
( $A < B$ ). This embodiment including a repeat counter  
4704 is such that an output pulse corresponding to the  
next input digital signal is not immediately formed as  
10 in the conventional systems but a pulse having a pulse  
width corresponding to the one input digital signal Din  
is subjected to repeated conversions in the number of J  
as designated by the repeat counter 4704.

Fig. 48 shows waveforms for explaining an  
15 example of operation of the digital-to-analog converter  
described above.

In the case where the digital input signal Din  
has eight bits, for instance, the period of the 10-MHz  
clock pulse CK is 0.1  $\mu$ s, and therefore when an 8-bit  
20 counter is used, one period is 25.6  $\mu$ s. As a result,  
when the input digital signal is a decimal 1, a high-  
level pulse is outputted during the first 0.1  $\mu$ s and a  
low-level pulse during the remaining 25.5  $\mu$ s. When the  
input digital signal is decimal 10, on the other hand, a  
25 high-level signal is outputted only during the first 1  
 $\mu$ s, and a low-level pulse during the remaining 24.6  $\mu$ s.  
In similar fashion, when the input digital signal is 100  
in decimal notation, a high-level signal is outputted

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Fig. 48 shows a case in which the number of repetitions J is 4. When an output signal converted into a pulse width is outputted four times repeatedly as mentioned above, a conversion output signal EOC corresponding to an input digital signal Din is outputted. In this way, in the case of four repetitions, the conversion time for forming four pulse width modulated outputs within the period of fetching the data read from the memory circuit 701 in the player 101 is  $25.6 \times 4 = 102.4 \mu s$ , thus making possible a conversion frequency of about 10 kHz. This is most suitable for reproduction of a news program, a conversation, a lecture or speech. In reproducing a music program of high sound quality, high frequencies up to about 20 kHz can be reproduced in the process of four repetitions if the frequency of the clock pulse CK is 20 MHz. If the number of repetitions is reduced by two while keeping the clock pulse CK at 10 MHz, on the other hand, high frequencies up to 20 kHz can be reproduced in similar fashion. In this way, a combination of the frequency of the clock pulse CK and the number of repetitions is matched with the sampling period of the input digital signal.

1           Incidentally, when a digital signal is  
inputted again in synchronism with a strobe STB in  
response to the conversion output signal EOC, a  
corresponding analog-to-digital conversion is effected  
5 in similar manner.

The pulse width modulated signal outputted from the comparator 4702 is smoothed by a low-pass filter 4708 including a resistor 4706 and a capacitor 4707, and is outputted as an analog signal Dout.

10 According to the present embodiment, such pulse width  
modulated signals are outputted in a plurality of  
numbers. As a result, even when the response is  
increased by setting the time constant due to the  
resistor 4706 and the capacitor 4707 to small value for  
15 improving the sound quality of the output signal, the  
ripple component is kept to minimum.

In the circuit according to the present embodiment which has the whole circuit capable of being configured of digital circuits, as compared with a case in which a digital circuit may be mixed with an analog circuit, the processes are simplified and the system may be configured of a CMOS integrated circuit or the like which is simple in the process and low in consumption.

Fig. 49 is a block diagram showing another  
25 embodiment of the digital-to-analog converter according  
to the present invention. The digital-to-analog  
converter according to the present embodiment is  
intended for simplifying the circuits.

1           According to the present embodiment, the  
comparator 4702 shown in Fig. 47 is done without and a  
pulse width modulated signal is formed corresponding to  
the digital signal by a down counter 4901 and flip-flop  
5   4902. Specifically, the down counter 4901 has set  
therein an input digital signal Din in synchronism with  
a strobe. As a result, the output signal Q of the flip-  
flop 4902 changes to high level, and the down counter  
4901 starts counting the clock by the strobe mentioned  
10 above. The down counter 4901 outputs a borrow signal BO  
and resets the flip-flop 4902 when the count thereof  
becomes zero. This borrow signal BO is sent to the  
input side as an end-of-conversion signal.

          The flip-flop 4902 is set simultaneously with  
15 the starting of counting the digital signal, and is  
reset when the clock corresponding to the digital signal  
is counted. As a result, the output signal Q of the  
flip-flop 4902 is converted into a pulse width modulated  
signal corresponding to the input digital signal.

20           A signal source inserted in the input side of  
the digital-to-analog converter according to this  
embodiment outputs a digital signal and a strobe  
corresponding to a predetermined sampling period like  
the memory circuit 701. As a result, the next digital  
25 signal is sent from the signal source not immediately  
after the conversion-over signal EOC is sent out, but on  
condition that a digital signal and a strobe are sent  
out in synchronism with the sampling period. Thus it is

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- 1 possible to produce a pulse width modulated signal  
corresponding to an input digital signal of a predeter-  
mined period by the setting operation synchronous with  
the strobe of the flip-flop 4902 and the resetting  
5 operation synchronous with the borrow output BO of the  
down-counter 4901.

Assume that the digital input signal Din has  
eight bits, for example. If a clock pulse CK of 10 MHz  
is used as mentioned above, the period thereof is 0.1  
10  $\mu$ s, so that the maximum count is 25.5  $\mu$ s when counted by  
an 8-bit down counter 4901. As a result, when the input  
digital signal is a decimal 1, the down-counter 4901  
counts only one, and therefore a high-level pulse is  
outputted only during the first 0.1  $\mu$ s and a low-level  
15 pulse is outputted only during the first 0.1  $\mu$ s and a  
low-level pulse during the remaining 25.5  $\mu$ s until the  
next strobe is inputted. Also, when the input digital  
signal is a decimal 10, a high-level signal is outputted  
only during the first 1  $\mu$ s when ten is counted, and a  
20 low-level signal during the remaining period of 24.6  $\mu$ s  
until a strobe is inputted. In similar fashion, when  
the input digital signal is decimal 100, a high-level  
pulse is outputted only during the period of 10  $\mu$ s when  
100 is counted, and a low-level pulse during the  
25 remaining period of 15.6  $\mu$ s before the next strobe is  
inputted. When the input digital signal is 255 which is  
a maximum decimal value, on the other hand, a high-level  
is kept only during the period of 25.5  $\mu$ s corresponding

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1 to the maximum count, and a low-level pulse during the remaining 0.1  $\mu$ s.

This pulse width modulated signal is smoothed by a low-pass filter 4905 including a resistor 4903 and a capacitor 4904 as mentioned above thereby to form an analog signal Vout.

In the case where a plurality of pulse width modulated signals are formed for a single input signal Din as in the embodiment of Fig. 47, an arrangement is made to generate a plurality of strobes having the above-mentioned period for a single input signal Din on the input side.

Fig. 50 is a block diagram showing another embodiment of a digital-to-analog converter according to the present invention.

The digital-to-analog converter shown in Fig. 49, in which a digital signal and a strobe are required to be formed at regular time intervals on input side, is limited in applications. According to the embodiment under consideration, by contrast, the period of the pulse width modulated signal outputted is defined by inserting an up-counter 5002. Specifically, the input D of the up-counter 5002 is supplied with 0 and cleared by a counter load pulse LD synchronous with the strobe, while a down-counter 5001 is supplied with an input digital signal Din from the counter load pulse LD.

The down-counter 5001 and the up-counter 5002 are supplied with the same clock CK. The borrow output

The controller 5004 is turned on by a strobe ST received in synchronism with the digital signal Din, thereby outputting a counter load signal LD for the down-counter 5001 and the up-counter 5002 and a set signal FR for the flip-flop 5003. Also, the controller 5004, in response to the clock CLK and a strobe inputted thereto, sends out a clock pulse to the down-counter 5001 and the up-counter 5002, and upon receipt of the carry output CAR from the up-counter 5002, sends out a conversion-over signal EOC, thus entering a ready state.

The flip-flop 5003 is turned on at the leading edge of the clock pulse. In the process, the flip-flop 5003 is held if the inputs J and K are 00 (both low in level), reset if the inputs J and K are 01 (low and high in level), set if the inputs J and K are 10 (high and low in level), and inverted if the inputs J and K are 11 (both high in level).

1           Now, the operation of the digital-to-analog  
conversion will be described in detail.

In initial state, all the counters and the flip-flop 5003 are reset. When a conversion start  
5 signal is inputted to the strobe input terminal ST of the controller 5004, the controller 5004 sets the output signal from the end-of-conversion signal terminal EOC to logic "1" and thus declares that conversion is going on.

The controller 5004 outputs a count load  
10 signal LD, thereby loading the down-counter 5001 with a  
digital signal, and the up-counter 5002 with 0 in  
synchronism with the leading edge of the clock CK. The  
down-counter 5001 and the up-counter 5002 start the  
counting operation at the end of loading.

15           The controller 5004 outputs a set signal FR of  
the flip-flop 5003 at a point later than the counter  
load signal LD by one half period of the counter clock.  
Since the borrow output BO of the down counter 5001 is  
logic "0", the flip-flop 5003 has the input J thereof in  
20 "1" state and the input K in "0" state, and is thus set  
in synchronism with the leading edge of the clock pulse.

The down counter 5001 performs the down-counting operation (-1) each time of arrival of the clock, and when the count becomes 0, outputs the borrow output BO. As a result, the borrow signal BO changes to logic "1", and the input J of the flip-flop 5003 to "0", and the input K thereof to "1". Thus the flip-flop 5003

1 is reset in synchronism with the leading edge of the clock pulse.

When the input digital signal Din is decimal 0, the borrow output BO of the down-counter 5001 and the set signal FR of the controller 5004 are outputted in the same timing. According to the present embodiment including an AND gate 5006 to give priority to the borrow output BO of the down-counter 5001. This AND gate 5006 inhibits the set signal FR of the flip-flop 5003 from the controller 5004. In this way, when the digital signal Din is decimal 0, no pulse is outputted from the flip-flop 5003. When the digital signal Din is 1 or more, in contrast, a pulse having a pulse width corresponding to the output Q of the flip-flop 5003 is outputted. The output signal thus subjected to pulse width modulation is smoothed by a low-pass filter 5007 thereby to form an analog signal Vout.

The up-counter 5002 continues the counting operation, and outputs a carry signal CAR when the count reaches the maximum. The controller 5004, upon receipt of the carry signal CAR, changes the conversion-over signal EOC to logic "0" thereby to end the whole series of the converting operation. Upon completion of the conversion, the next digital signal is inputted. Specifically, in the case where the up-counter 5002 is provided as described above, an address signal is generated by the end-of-conversion signal EOC following

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As explained above, when the input digital signal and the strobe are inputted, the above-mentioned operation is repeated to form an analog signal  $V_{out}$  corresponding to the input digital signal  $D_{in}$ . The controller 5004 raises the end-of-conversion signal EOC to high level and notices the fact to an external circuit during the conversion process, and continues the conversion without answering to a strobe ignoring the notice.

In reducing the ripple component of the analog conversion output  $V_{out}$ , a repeat counter or the like is provided for each conversion start signal like a strobe to repeat a designated number of digital-to-analog conversions as mentioned above. In the case where no input of a digital signal  $D_{in}$  is assured during this repetition, a register should be provided to fetch an input digital signal in the same manner as described above.

The embodiments explained with reference to Figs. 47 to 50 may be applied widely as a signal converter for converting a digital signal into a pulse width modulated signal as well as to a digital-to-analog  
25 converter.

Fig. 51 is a basic block diagram showing an embodiment of a switch input circuit for the player 101

1 used with the digital information system described  
above.

As described already, the player 101 is  
reduced in size and thickness so as to be compatible  
5 with an IC memory card or the like. As a result, it is  
considered important to reduce the switches or the like  
for designating an operation mode. In view of this,  
according to this embodiment, signals 5103-1 to 5103-n  
for designating the states 1 to state n are formed by a  
10 state controller 5102 receiving an on/off signal of a  
key switch 5101. By doing so, a package of switches can  
be accommodated in a limited space of the small and thin  
player 101 as described above.

Fig. 52 is a block diagram for explaining an  
15 embodiment of a specific configuration of a state  
controller.

According to this embodiment, an on time of  
the switch 5101 is judged by the state controller 5102.  
The state controller 5102 forms a signal 5201-1 for  
20 turning on state A unconditionally once the switch is  
turned on regardless of the on time T of the switch  
5101. The state controller 5102 forms a signal 5201-2  
for turning on state B when the on time T of the switch  
5101 is smaller than a predetermined time length M ( $M >$   
25 T). The state controller 5102 further forms a signal  
5101-3 for turning on state C when the on time T of the  
switch 5101 is judged to be larger than a predetermined  
time length M ( $M \leq T$ ). By combining the signals 5101-1

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1 to 5101-3 representing these three states A to C, the  
playback control operation mentioned below is realized.

Fig. 52 is a schematic diagram for explaining  
this operating mode.

5           The player 101 is set in a stop state  
immediately after power is thrown in. In this state  
5302, assume that the switch 5101 is turned on. A  
signal 5301a indicating an unconditional state A  
regardless of the on time T is formed to set the player  
10 101 in playback state 5303. In this playback state  
5303, it is necessary to select one of two choices, one  
to change to a pause state 5305 and the other to return  
to the stop state 5302. When the switch 5101 is turned  
on again, the signal 5301b indicating the state A is  
15 formed and the time judgement 5304 is started, thereby  
judging the time T turned on. If the judgement is a  
signal 5301c indicating the state B, the player 101 is  
set to the pause 5305. If the judgement is a signal  
5301e indicating the state C, on the other hand, the  
20 player 101 is returned to the stop state 5302. In the  
stop state 5305, the only meaningful operation is to  
return to the playback state 5303, and therefore the  
switch 5101 is only turned on so that the playback state  
5303 is restored by the signal 5301d indicating the  
25 state A as described above.

In the case where a plurality of types of  
operation are designated by a switch, the disadvantage  
is a complicated operating procedure. According to the

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Fig. 54 is a block diagram showing another  
15 embodiment for explaining a specific configuration of a  
state controller.

According to this embodiment, the number of turnings on of the switch 5101, not the on time T of the switch 5101 as mentioned above, is judged by the state controller 5102. The state controller 5102 counts the number of turnings on of the switch 5101 and forms a signal 5401-1 for entering state A if the number of turning on is one. When the number of turnings on of the switch 5101 is two, on the other hand, a signal 5401-2 for entering state B is formed. By combining the signals 5401-1 and 5401-2 indicating two states A and B in this way, the playback control operation mentioned below is realized.



1            Fig. 55 is a schematic diagram for explaining  
the operating mode.

Immediately after power is switched on, the player 101 is set to the stop state 5302 as described above. When the switch 5101 is turned on once under this state 5302, a signal 5501a indicating the state A is formed to set the player 101 to playback state 5303. In this playback state 5303, it is necessary to select one of the two choices, one for changing to the pause state 5305 and the other for returning to the stop state 5302. When the switch 5101 is turned on once, the signal 5501b indicating the state A is formed to set the player 101 to the pause state 5305. As an alternative, if the switch 5101 is turned on twice, the signal 5501e indicating the state B is formed to return the player 101 to the stop state 5302. In this embodiment, the stop state 5302, as well as the playback state 5303, may be restored from the pause state 5305. As a result, if the switch 5101 is turned on once in the pause state 5305, a signal 5501c indicating the state A is formed to shift the player 101 to the playback state 5303. When the switch 5101 is turned on twice in the pause state 5305, a signal 5501d indicating the state B is formed to shift the player 101 to the stop state 5302. According to this embodiment, too, the operating procedure is easily mastered by plotting corresponding display units and arrows in Fig. 53 as in the preceding embodiment.

1           Fig. 56 is a block diagram showing an  
embodiment in which the information to be stored, which  
may be available in a plurality of number of pieces, is  
divided (by block) for storage, and in playback mode,  
5 selective playback, i.e., what is called the head  
search, is made possible by designating a desired block  
by an operating switch or the like. This embodiment, in  
addition to a data memory 5610 and a data address  
counter 5611, includes a block address memory 5601 for  
10 setting the block address in the data address counter  
5611 for determining a memory address of the data memory  
5610, a block address counter 5602 for designating the  
address of the block address memory, a decoder 5603 for  
decoding the contents of the block address counter 5602,  
15 a display unit 5604 for displaying the contents decoded,  
an operating switch 5607 for selecting a block, and a  
chatter killer for removing chatters. This circuit  
section is supplied with a PLAY signal (a pulse with the  
width of 100 ns) for indicating the start of  
20 storage/playback and a RECSTOP signal (a pulse with the  
width of 100 ns) for indicating storage stop.

Now, the operation of this circuit will be  
explained. To facilitate the understanding, the count  
on the block address counter 5602 is assumed to be zero.  
25 If the storage mode is started in this state, the data  
are stored sequentially from the address 0 of the data  
memory 5610. Assume that the storage stop is designated  
at a given timing. First, the block address counter

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1 5602 is incremented (the contents become 1) at the  
leading edge of the RECSTOP signal, and further, the  
contents of the data address counter 5611 are stored at  
the address 1 of the block address memory 5601 through a  
5 100ns delay line 5608 (the head address of the second  
data is involved). When the storage mode is entered in  
order to store another data and a PLAY signal is  
outputted, the contents of the address 1 of the block  
address memory 5601 stored previously are loaded (set)  
10 directly in the data address counter 5611 as a head  
address, so that the second data is stored sequentially.  
Each time the storage stop is designated, the contents  
of the data address counter 5611 are sequentially  
written into the block address memory 5601. The  
15 playback operation, on the other hand, is effected in  
the manner that will be described now. First, when it  
is desired to reproduce an intended block, say, the  
second data, the block address counter 5602 is  
incremented each time the operating switch 5607 is  
20 pressed, and the contents thereof are displayed on a  
numerical display 5604 (which may be a simple LED)  
through the decoder 5603. Until the intended address 1  
(the second address is stored in the address 1) is  
displayed, the operating switch 5607 continues to be  
25 pressed, and when the address 1 is displayed, stops  
being pressed. When the playback is designated in the  
next instant, the PLAY signal is outputted, and the  
contents of the address 1, i.e., the head address having

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1 the second data stored therein, is loaded (set) in the  
data address counter 5611 to proceed with the reading.  
When it is desired to reproduce (or store) the first  
data, the incrementing operation of the block address  
5 counter 5602 is suspended at the time point when zero is  
indicated on the display 5604, whereby the all-zero  
output of the decoder 5603 becomes low in level, so that  
the PLAY signal is passed through the AND gate 5606  
thereby to clear the data address counter. As a result,  
10 the data memory 5610 starts the playback (or storage)  
operation from the address 0, and the first data is  
reproduced (or stored).

As explained above, according to the present  
embodiment, a desired block can be selected by a simple  
15 operation, thus providing a system very easy to operate.  
Another feature of this embodiment lies in that since  
the block length can be determined exactly as desired,  
and therefore the data memory 5610 can be utilized  
without waste very efficiently. This is due to the fact  
20 that the performance of a semiconductor memory is fully  
used taking advantage of the characteristics thereof,  
and shows an example of effectiveness of the system  
according to the invention. Although a memory is  
divided into the data memory 5610 and the block address  
25 memory 5601 in this embodiment, they may be arranged as  
a single memory unit with equal effect.

Fig. 57 is a schematic diagram showing an  
embodiment of a storage area management system of the

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1 memory circuit 701 of the player 101.

In order to assure efficient use of the storage capacity of the memory circuit 701 mounted in the player 101 against a plurality of pieces of information, the memory circuit 701 is divided into a contents area and a data area. The contents area, though not specifically limited, has four contents 5701a to 5704a, capable of storing block addresses BA0 to BA3 respectively. The contents 5701a to 5704a are selected by program select signals PSL1, PSL2 and the like thereby making it possible to write or read the block addresses BA0, BA1, etc.

In the above-described digital information system, the terminal device 100, when connected with the player 101, accesses the contents area and reads an effective block address. As a result, the terminal device 100 is in a position to know a vacant area of the memory circuit 701 of the player 101. When a new digital signal to be received is designated, the block address is stored in the vacant contents area while at the same time storing a digital signal in the vacant area.

If the contents are in short supply or the vacant storage capacity is lacking for the digital signal received, a digital signal that has been already stored and that may be erased by display is selected, and by erasing the particular digital signal, a new digital signal is inputted. In the process, the digital

1 signal that is already stored in the player 101 is also  
read out, and an address is allocated in such a manner  
as not to cause any vacancy of storage area in  
accordance with the storage capacity of the new digital  
5 signal.

In Fig. 57, the contents 5701a are addressed  
by a program access signal PSL1, so that the block  
address BA0 stored therein is read and set in the  
address counter 703. Assuming that the block address  
10 BA0 set in the address counter 703 is the data block  
5701d of the head address of the data area as shown by  
solid line, for example, the ID code 5701i at the head  
of the block and subsequent addresses start to be read  
sequentially. The last address of the data, though not  
15 specifically specified, has an end mark 5701e stored  
therein, by detection of which the reading process is  
ended. In this configuration, it is sufficient to store  
only the head address in the contents and therefore the  
address information can be reduced.

20 Also, the contents 5702 are accessed by the  
program select signal PSL2, and the block address BA2  
stored therein is read and set in the address counter  
703. In the case where the block address set in the  
address counter 703 makes up an intermediate block as  
25 shown by dotted line, for instance, the addresses having  
the head ID code 5702i of the particular block and  
subsequent addresses start to be read in that order.  
The last address of the data 5702d has the end mark

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1 5702e stored therein in the manner similar to the  
preceding case, and the reading process is ended upon  
detection of the end mark 5702e.

Assume that some data blocks storing the  
5 above-mentioned two types of program are vacated by  
erasure of a digital signal corresponding to the  
contents 5701a or otherwise, for example. The terminal  
device 100 changes the block address BA2 of the contents  
5702a to an address of the end mark 5701e of the data  
10 area corresponding to the contents 5701a, while at the  
same time writing a corresponding digital signal. By  
doing so, a digital signal corresponding to the program  
newly received is usable successively for the remaining  
vacant areas.

15           The player 101 can be connected with the  
terminal device 100 so that the contents area and the  
data area may be cleared and a new digital signal may  
be stored. In such a case, desired programs may be  
reserved by designating a no-erasure on the player  
20 101 side or a no-erasure program as an operation of  
receiving of a digital signal with the terminal device  
100.

Fig. 58 is a schematic diagram showing another embodiment of the storage area management system of the memory circuit 701 of the player 101.

According to this embodiment, a digital signal is stored and managed by a contents memory 5801 and a

1 data memory 5802. The contents memory 5801 can store a  
maximum of four types of digital signals (programs)  
including contents 1 to 4, for example. The contents  
memory 5801 may store only the head address as in the  
5 aforementioned embodiment or the contents information in  
addition to the end address or ID code. This contents  
information, though not specifically limited, includes  
character information, so that the program contents can  
be displayed by characters with a liquid display unit  
10 mounted in the player 101.

Each content of the contents memory 5801 and  
the data area of the data memory 5802 is arranged as  
desired in such forms as data 2, data 1, data 4 and data  
3, for example, from the head address side of the data  
15 memory 5802 in the order of storage. Specifically,  
digital signals are stored in the data memory 5802 in  
the order of designation.

Fig. 59 is a block diagram showing the  
essential parts of an embodiment of the player 101 with  
20 the contents function added thereto.

The controller 5906 includes a switch 5907 for  
designating contents (designating programs) in addition  
to the switch 5908 for operation control mentioned  
above. When this switch 5907 is turned on, though not  
25 specifically limited, a +1 pulse is supplied to the  
contents address counter 5901, and the contents memory  
5801 is accessed. The contents information read out of  
the contents memory 5801 is stored in the contents

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1 register 5909 whereby such characters as title are  
displayed on the liquid crystal display 5910.

The head address read out of the contents  
memory 5801 is set in the address counter 5902 of the  
5 data memory 5802, while the end address and the ID code  
are loaded in the registers 5903 and 5904 respectively.  
The ID code is transmitted to the controller 5906 and is  
decoded for automatically setting the sampling  
frequency, the data length, the stereo/monaural mode and  
10 the like.

The address signal outputted from the address  
counter 5902 is used for accessing the data memory 5802  
on the one hand and is supplied to the comparator 5905  
on the other hand. The other input of the comparator  
15 5905 is supplied with the last address loaded in the  
register 5903. As a result, when a digital signal  
(data) corresponding to the designated contents is  
completely read, this fact is detected by the comparator  
5905 and an end signal is inputted to the controller  
20 5906, thereby ending the operation of reading a series  
of digital signals.

In the above-mentioned indexing function, the  
number of contents may be four or as desired. If such a  
number is the square  $N$  of 2, however, a binary address  
25 counter can be conveniently used directly and selection  
is facilitated. Also, in the case where the contents  
memory 5801 is provided separate from the data memory  
5802, they are accessible in parallel independently of

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1 each other thereby to simplify the control of the  
address counter. The contents memory 5801, as in the  
embodiment of Fig. 57, may be course be configured by  
the use of a predetermined storage area of the data  
5 memory 5802.

Fig. 60 shows an embodiment of the player 101  
according to the present invention similar to that of  
Fig. 7. This embodiment comprises a one-chip integrated  
circuit 6001 in the form of IC or hybrid IC defined by  
10 one-dot chain including a multiplexer 702, an address  
counter 703, a controller 704, a parallel-to-serial  
converter 705, a low-pass filter 706, a digital-to-  
analog converter 707 and an amplifier 708 except for the  
memory circuit 701 of the player 101. This one-chip  
15 integrated circuit includes a signal and a terminal for  
realizing the data transfer of the digital information  
system described above, a signal and a terminal for  
controlling the memory, a signal and a terminal for  
outputting an analog audio signal, a signal and a  
20 terminal for supporting the operation against the one-  
chip integrated circuit, a signal and a terminal for  
indicating the state of the one-chip integrated circuit,  
and a signal and a terminal for supplying power to the  
one-chip integrated circuit. Also, the configuration of  
25 a one-chip integrated circuit need not include all the  
functions described above and is not confined  
specifically.

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1           This embodiment is reduced in size to such an  
extent that a body circuit including a cell can be  
entirely packaged in the ear portion of the headphone  
with microphone used by the telephone operator or the  
5 like. At the same time, actual measurement of the power  
consumption is only about 50 microwatts in standby state  
and about 20 milliwatts at the time of playback, thus  
realizing a system very small in size and extremely  
small in power consumption. This indicates that the  
10 continuous playback operation of 30 hours or longer is  
possible even with a small-capacity (180 mAh) button-  
type lithium cell is used, or that a given data stored  
and left to stand may be reproduced effectively 450 days  
later. There is still a room for remarkable improvement  
15 of these values by technological advance, with the  
probable result that a record may be held over several  
years, the playback operation over one hundred hours may  
be made possible, or a still smaller and lighter system  
may be realized.

20           In the case where the controller is  
incorporated in a one-chip integrated circuit, the  
problem may be posed that the storage capacity of a  
directly controllable memory is limited. In order to  
obviate this problem, as shown in Fig. 61, the control  
25 signal and the terminal of the memory may be provided  
with an extending signal and another terminal as an  
option, whereby it is possible to enlarge the storage  
capacity of the memory. In the case where the address

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1 generated by the address counter 703 incorporated in the  
one-chip integrated circuit is 23 bits (a data is  
assumed to have eight bits) as shown in Fig. 60, for  
instance, the storage capacity of the memory is  
5 8,388,608 bytes at maximum. If it is desired to double  
the storage capacity to 16,777,216, an address extender  
including an extended address counter 6101 operated in  
cooperation with an internal address counter 703 and an  
extended multiplexer 6102 operated the same way as an  
10 internal multiplexer 702 is inserted outside of the one-  
chip integrated circuit to extend the address applied to  
the memory to 24 bits.

Fig. 62 is a block diagram showing a self-  
diagnosis circuit for automatically discriminating a  
15 defective bit of the memory in the player 101 and  
skipping the defective bit.

In the player shown in Fig. 7, the memory  
circuit 701 has added thereto a self-diagnosis circuit.  
This self-diagnosis circuit includes a multiplexer 6202  
20 for selecting the data inputted to the memory circuit  
701 and the two types of data patterns "AA" and "55" for  
testing the memory, a ternary counter 6201 for supplying  
a selection signal to the multiplexer 6202, a buffer  
6204 for connecting the output of the multiplexer 6202  
25 to the memory, a delay line 6206, an address counter  
703, a comparator 6203 and a first-in first-out memory  
6207. Signals inputted to and outputted from this  
circuit section include an input data from the terminal

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1 device 100, an output data from the memory, a write  
strobe signal (WE) from the controller to the memory, a  
RUN signal for indicating "under storage/playback", and  
two types of memory test pattern data "AA" and "55" as  
5 an input. A skip address output and a playback clock  
input are for skipping the defective portions (defective  
addresses) of the memory in the process of reading  
during the playback operation. Immediately after the  
stored data is changed, the write strobe signal (WE) is  
10 inputted with a pulse width of 100 ns (the repetitive  
frequency of 8 kHz), clears the ternary counter 6201  
through the AND gate 6213, and is connected to the  
control terminal of the buffer 6204 and the WE (write  
enable) terminal of the memory through the AND gate 6214  
15 and the inverter 6205. The buffer 6204 is a device  
which is in a high impedance state when the control  
terminal is at a high level, and the input thereto is  
reflected in the output terminal thereof only when the  
control terminal becomes low. The data terminal (DIO)  
20 of the memory, on the other hand, outputs the contents  
of a designated address when the WE terminal is high in  
level, while when the WE becomes low, the DIO terminal  
switches to a state capable of accepting a data input,  
thereby writing the data input of the DIO terminal into  
25 a designated address. When the data on the input and  
output sides of the buffer 6204 immediately after the WE  
pulse signal has returned to high level (exactly, after  
the lapse of 50 ns as an access time of the memory),

1 therefore, a normal data should have been written into  
the memory. If the two data fail to coincide with each  
other, by contrast, it indicates that a normal data has  
not been written into the memory. In order to make this  
5 judgment, a comparator 6203 is inserted which is so  
logically configured that the Y output thereof becomes  
high in level when the contents at the A and B input  
terminals fail to coincide with each other, and the Y  
output of this comparator 6203 is supplied as an input  
10 to the AND gate 6210. In this configuration, the output  
of a NOR gate 6205 is also inputted to the pulse delay  
line 6206 with inverter function. By this delay line  
6206, a WE' pulse about 200 ns delayed is outputted and  
inputted to the other input terminal of the AND gate  
15 6210. In the processes, if the no-coincidence output is  
at low level, i.e., if the data is normally written into  
the memory 710, the AND gate 6210 outputs no signal.  
The ternary counter 6201 is reset at the time of input  
of a WE pulse thereto (although the clock input CP is  
20 also supplied with a pulse, the clearing operation is  
given priority), and both the QA and QB outputs thereof  
are at low level with the multiplexer 6202 selecting the  
pattern "AA" (10101010 sequentially from the seventh  
power of 2 bits side in hexadecimal or binary notation).  
25 Therefore, the data normally written into the memory  
circuit 701 makes up the first test pattern. Since the  
QB output (first power of two bits) of the ternary  
counter 6201 is at low level, this output is raised to

1 high level at the inverter 6216. The AND gate 6211  
passes the WE', which passing through the OR gate 6214,  
counts up the ternary counter 6201 whereby the  
multiplexer 6202 selects the test pattern "55" (01010101  
5 sequentially from the seventh power of 2 bits side in  
hexadecimal or binary notation). At the same time, the  
output of the OR gate 6214 is inputted to the NOR gate  
6205 and functions as a write pulse for the memory.  
Subsequently, when the test pattern "55" or the stored  
10 data (input data of the memory) is normally written, the  
AND gate 6211 is inhibited (since the QB output of the  
ternary counter 6201 is raised to high level), so that  
the round loop mentioned above is released. Instead,  
the WE' pulse is passed through the AND gate 6212, and  
15 after counting up the address counter 703, the next  
write pulse (WE) from the controller is awaited. In the  
case where the Y output (no-coincidence output) of the  
comparator 6203 is at high level, i.e., in the case  
where no normal data has been written into the memory  
20 circuit 701, the WE' pulse is passed through the AND  
gate 6210, and the associated contents of the address  
counter 703 are written into the first-in first-out  
memory 6207, while at the same time being inputted to  
the NOR gate 6205 and the OR gate 6213, thereby  
25 repeating once again the same operation as when the WE  
pulse is inputted. This repetitive operation is  
continued until a data is normally written into the  
memory circuit 701 (this repetitive operation requires

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1 about 300 ns and the WE input period is about 125  $\mu$ s.  
Therefore, the number of repetitions actually allowed is  
about 400 in the first pattern check, i.e., by  
generation of an error at the time of writing the  
5 pattern "AA", or about 200 in the second pattern check,  
i.e., by generation of an error at the time of writing  
the pattern "55".)

According to this embodiment, it is possible to use a semiconductor chip which otherwise might be discarded as a result of inspection when only several bits of large capacity memory cells of megabit class such as four or 16 megabits are defective, and therefore a very inexpensive system is provided. The basic concept here is to conduct inspection before writing and utilize any defective bit by the use of the result of inspection, and various modifications and applications are of course possible by use of this concept. When a defective bit fixed to "1" at the time of writing "1" is detected as a result of inspection, for instance, that bit may be used as "1" as it is.

If the operation of the multiplexer 6202 in Fig. 62 is fixed (QA output of the ternary counter 6201 is fixed to low level and the QB output thereof to high level), a simple self-diagnosis circuit may be  
25 configured for checking while writing into the memory by use of only a write data.

Also, the present embodiment is effective especially when the recording function (also, image or

[illegible]



Fig. 67 is an outside view showing a specific embodiment of a digital information system according to the present invention. In Fig. 67, the same component parts as in Figs. 1, 3, 7, 10 and 59 are designated by the same reference numerals respectively and will not be described in detail.

The player 101 also has a high-speed fourth clock for transferring a digital signal from itself to the memory. In the case where the terminal device 100 is used in connection with the player 101, however, the fourth clock may be replaced with the second clock. At least in that case, the fourth clock may be done

1 without. Of all these clocks, the first and third  
clocks for recording or playback may be variable. In  
music applications, the audio sampling frequency may be  
increased in speed and a higher sound quality is thus  
5 expected. In the case of conversation, on the other  
hand, the sampling frequency may be decreased in speed  
to save the memory consumption.

In the application shown in Fig. 67, for example, a given audio file is selected from the terminal device 100 acting as a parent, is written at high speed with the second clock for transferring information to the player 101 as large as an electronic notebook making up a child, and is further transferred and recorded in a small memory card or an IC card making up a grandchild at a memory by the high speed fourth clock. The contents thus recorded may be shared with other players 101, electronic notebooks or the like.

Also, the software makers or developers may supply audio information, processing programs and the like in the form of memory card or IC card. Further, it is possible to add an optional function to the player 101 such as for converting an audio signal to a sentence or storing a sentence in the memory section. The grandchild card is not limited to the one using a semiconductor memory, but various media such as ultra-small optical or magnetic disks may become available in the future.

Numeral 406 designates a speaker, and numeral 6702 an operating section for recording and playback operation. The terminal device 100 itself has a recording and playback function. The terminal device 100, for instance, is made up of a multi-purpose audio recording and playback system at least having the

1 functions of FM, AM, TV, radio, optical disk, magnetic  
disk, digital audio tape or timer-reserved recording.  
The multi-medium functions of the terminal device 100  
may be promoted by adding the digital information system  
5 according to the present invention.

The terminal device 100 may of course be of  
either free-standing or portable type depending on the  
environment involved. Also, the digital information  
system according to the present invention may be  
10 introduced to the telephone or the like system to  
acquire a great amount of information through the  
automatic answering telephone function.

The present embodiment represents a  
comparatively small type of system for home use.

15 Fig. 69 is an outside view showing a specific  
embodiment having the most conspicuous features of a  
digital information system according to the present  
invention. In Fig. 69, the same component parts as in  
Figs. 1, 3, 4, 7 and 10 are designated by the same  
20 reference numerals respectively, and will not be  
described in detail. The present embodiment has the  
features mentioned below in order to realize simple  
operability. Though not specifically shown in Fig. 69,  
a touch panel is employed for the liquid crystal display  
25 303 to display the operating procedure and the functions  
of the operating switches on the screen, thus minimizing  
the requirement of operating switches (limited to the  
confirmation switch described later) by a tiered

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15                Furthermore, the terminal device 100 is  
connected with the player 101 by a connector conforming  
to the JEIDA or equivalent standard.

The present invention is not limited to the monochromatic display of the graphic screen or characters on the liquid crystal display unit 303 of the terminal device 100 as according to the present

1 embodiment, but still images or animation may be displayed in color with equal effect.

The effects obtained from the embodiments described above are as follows:

5 (1) In receiving/delivering a digital signal, a  
player is directly connected one-to-one with a digital  
signal source, so that a specified digital signal is  
directly received and stored in a memory and the digital  
signal stored independently in the memory is reproduced.  
10 In this configuration, the player receives the digital  
signal and reproduces it independently, so that the  
value of the digital signal delivered is exhibited in  
direct form.

(2) As a result of the effect described in (1) above, the digital information as a commodity or the like can be easily processed or produced or the selling system thereof easily set up.

(3) As a result of the effect described in (1) above, the value of the digital signal itself received/  
20 delivered is recognized as a commodity or the like, and the player has a simple function of reproducing the particular value. The player thus has a simple configuration and is easily operated by any one.

(4) A digital signal is received from a digital  
25 signal source by a terminal device through a communica-  
tion channel or an appropriate storage medium. A player  
and a connector are connected with the terminal device  
to receive/deliver a digital signal, whereby a digital

(5) A magnetic disk memory having a comparatively large storage capacity is used as a backup memory for the terminal device, and the digital signal large in the amount of receiving/delivery or updated with time is stored in a buffer memory configured of a semiconductor memory accessible at high speed, thus realizing an efficient receiving/delivery of a digital signal.

(7) The terminal device is provided with the function of monitoring a part of the digital signal for a predetermined length of time, thereby preventing a selection error or facilitating the selection of an intended digital signal.

(9) The digital signal received/delivered has added thereto an ID code, whereby the playback

(14) As a part of the memory section of the player, a thin card-like memory is replaceably mounted. This makes it possible to enlarge the storage capacity or reproduce a program configured of various ROMs as required, thereby realizing a variety of functions.



1 (15) The security system may be configured in such  
a manner that at least one bit of digital signal at the  
address input section or the data input and/or data  
output of the digital signal memory circuit is inverted,  
5 or is replaced by another bit, thereby realizing a  
confidentiality with a simple configuration.

(16) The player is provided with a storage area or  
a contents memory for storing contents information  
including a storage address corresponding to a plurality  
10 of digital signals, and a data area or a data memory  
accessible by the storage address, so that a digital  
signal as a plurality of types of information is  
efficiently stored in the memory.

(17) The operation of the player is controlled by  
15 designating a plurality of types of operating modes by a  
combination of on time or the number of turnings on,  
thereby realizing a miniaturization and reduced  
thickness of the player.

(18) The voice interval of a digitized audio signal  
20 is detected, and the digital signal inputted to a  
digital-to-analog converter is forcibly replaced by a  
signal corresponding to an AC-like 0 level during the  
particular voice interval, thereby eliminating a  
cacophonous quantizing noise.

25 (19) A voice interval is detected on the basis of  
output signals of a pair of comparators for comparing a  
digital signal corresponding to adjustable positive and  
negative levels considered voiceless with a reproduced

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(20) The voice interval of a digitized audio signal  
5 is detected and the length thereof is extended or  
enlarged thereby to permit a slow playback with high  
sound quality.

(22) The voice interval of a digitized audio signal is detected, and by shortening the length thereof, a fast playback is made possible while maintaining a high sound quality.

(24) By replacing a voice interval of a digital signal with a voice interval code data and voice interval time data, data compression is made possible, while at the same time producing a voice interval corresponding to the time data. Further, by adding a simple circuit, the time data is enlarged with a longer

25 (28) As a result of the effect described in (27) above, a data compression or extension circuit can be realized with a simple circuit including a subtracter,

(29) By using a data conversion system and circuit as mentioned above, a small and lightweight player is realized for reproducing the acoustic signal stored in a memory.

(31) A digital signal supplied in a predetermined period corresponding to the maximum value of the digital signal is inputted to a down counter to form a reference time pulse by a simple circuit, thereby producing a pulse width modulated signal corresponding to the digital signal.

(32) A predetermined period corresponding to the maximum value of the digital signal is formed by an up counter for performing the counting operation corresponding to the digital input signal in response to the reference time pulse, whereby a digital signal corresponding to the address conversion can be inputted with a simple configuration.

The present invention which has been explained above with reference to embodiments is not limited to such embodiments and various modifications are of course possible without departing from the spirit of the invention. In a digital information system, for example, a digital signal may be not only sold as a commodity but also offered free of charge to a person specified by the player as one of the services offered by securities firms, financial institutions or the like. As an alternative, the whole digital signal may be utilized for receiving/delivery of information required periodically or from time to time by a collective agreement. Also, the digital signal may be in such a

1 form as capable of being transmitted by an audio signal  
like the data required for language study or memoriza-  
tion for various test objects.

Further, a digital information system  
5 mentioned above makes it possible to build a very  
efficient and timely futuristic media for supplying  
various information and amenities using a digital audio  
signal in place of the conventional newspaper, weekly  
magazines, etc. using prints.

10 The player may be constructed of a connector  
connectable with an extending ROM card or RAM card. In  
such a case, in order to prevent the player itself from  
being increased in thickness, the ROM or RAM card may be  
made up of a thin plastic card with a memory chip built  
15 therein. The ROM card is convenient for a music program  
or language learning. The RAM card makes up effective  
means for enlarging the memory capacity. The RAM card  
is effective, for example, when receiving a music  
program or the like with a long performance time.

20 The configuration, function, etc. of the  
terminal device and the player used with the digital  
information system may take various forms of embodiment.  
The memory built in the player may be a static RAM or a  
combination of a dynamic RAM and an automatic refresh  
25 circuit as well as a pseudo-static RAM mentioned above,  
or as a further alternative, may be a flash memory  
(EEPROM) or any of various ROMs or a small, thin  
rewritable optical disk.

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- 1           The digital signal may be character or image information, or a combination of an audio signal and a character or image information as well as an audio signal mentioned above. For reproducing such character
- 5 or audio information, a display unit is required. A display unit, though not specifically limited, may include a thin and lightweight liquid crystal display unit.

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